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A field study was made of the acoustical environment of schools designed for increased flexibility to meet the spatial requirements of new teaching methods. The object of the study was to define all the criteria for the acoustical design of this type of classroom including the determination of--(1) minimum acoustical separation required for effective group and individual work, (2) tolerable sound levels, and (3) objectional types of sounds. The resulting data was intended as a guide for architects, engineers, acoustical consultants, and educators. Questionnaires dealing with the aural environment of their schools were sent to teachers in thirty-seven schools in all parts of the country. Teams of acoustical consultants then analyzed each school to accurately determine noise reduction, reverberation, speech interference level and articulation index. The collected data, discussion, and conclusions are presented for each school studied. This document previously announced as ED 014 206. (JT)

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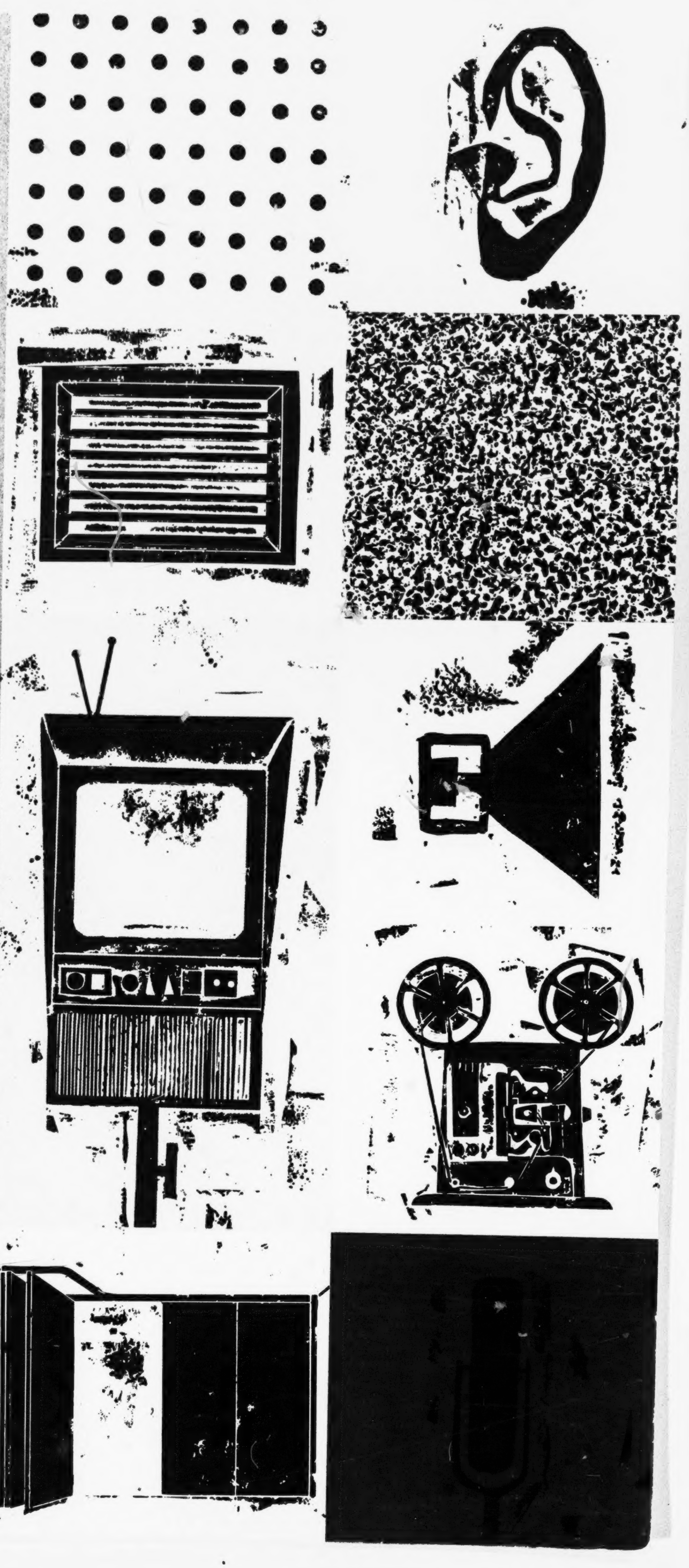
ACOUSTICAL ENVIRONMENT OF SCHOOL BUILDINGS



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ACOUSTICAL ENVIRONMENT OF SCHOOL BUILDINGS

by Dariel Fitzroy - A.S.A. and John Lyon Reid - F.A.I.A.

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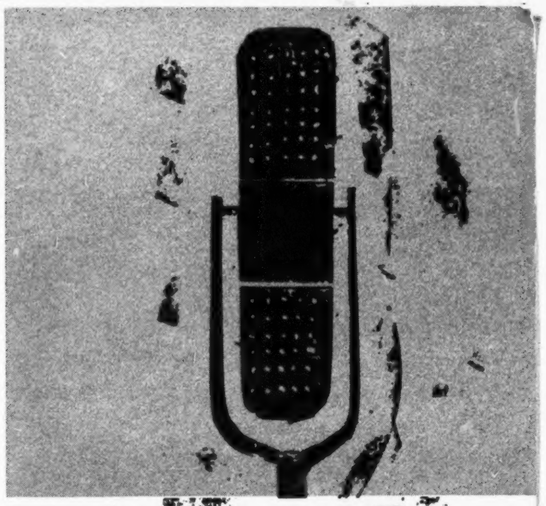

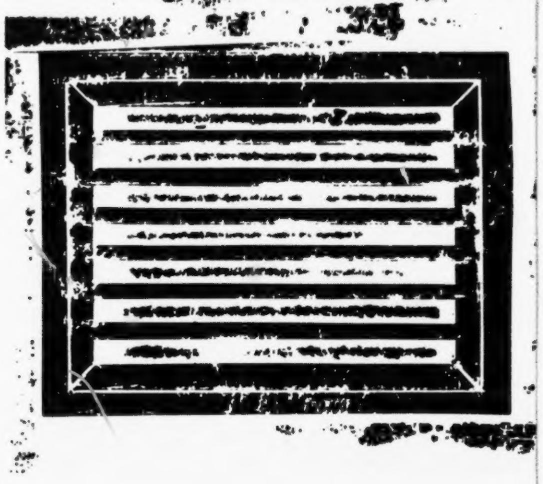

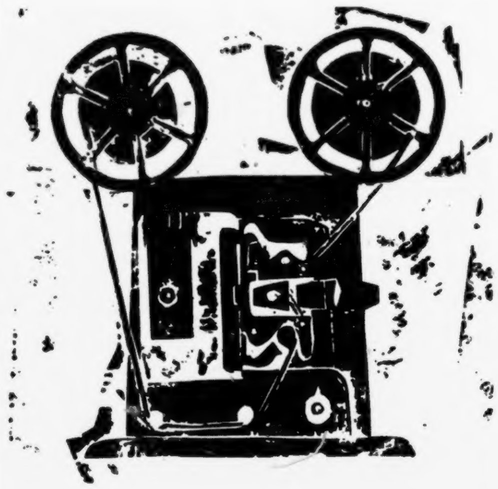

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1
FOREWORD

This report was born of controversy and will bear more controversy. It concerns acoustics of academic space in schools. Unemotional as the subject may sound, it nevertheless is currently one on which deeply divergent views are held by many of those involved: school administrators, architects, and acoustical engineers.

The authors of this report are John Lyon Reid, an architect with great experience in schoolhouse design, who is an outstanding innovator in the field, and Dariel

Fitzroy, the acoustical engineer who has collaborated with Reid in planning some of the most significant schoolhouses in the United States.

The material presented here is the result of many months of field measurement and study and the analysis of the statistical data gathered therefrom. These data will nonetheless stir up conflict in the field because they differ so completely with the conventional wisdom in the field of architectural acoustics.

Nevertheless, Educational Facilities Laboratories considers this report to be of major value to architects and acoustical engineers, particularly those interested in the design of more open or flexible buildings, where the development of a high degree of acoustical separation may be either impossible or extraordinarily expensive.

For many years the degree of acoustical isolation needed for a successful teaching environment has been determined by the repetition of untested standards handed down from one authoritative study to another without research substantiations. This report is based on actual conditions existing in schools throughout the country.

Educational Facilities Laboratories

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PREFACE

There is a trend in the recently constructed school buildings in the United States to design interior spaces which are more open. In the search for relationships in space and function between rooms, which arise from newer teaching methods, partitions are not as frequently employed as they used to be to isolate one space from another. One of the problems presented by this trend is the design and treatment of the acoustical environment.

One of the criteria which has been generally accepted and used has been that an acoustical separation of 40 decibels between adjoining teaching spaces is desirable. The acceptance of this criterion makes it difficult to relate two adjoining teaching areas by opening them widely into each other, or by separating them with folding partitions. More recently, however, several manufacturers have placed folding partitions on the market whose rating in terms of acoustical separation has been much higher than was formerly available. The cost of most of these partitions, while not excessive, is high enough to represent a problem to the financially pressed school districts of America.

Newer teaching methods require groups of students of varying sizes to work together; these groups break up with some frequency and form again into new groups. Learning activities vary widely and include lectures to large and small groups, recitations, conferences and discussions, teacher-student consultations, individual study, the making by students of models, charts, posters, and displays, the gathering and study of specimens, the typing of reports, and the use of an increasing number of new audio-visual teaching devices. It is difficult, and sometimes impossible, for an architect to design separate rooms that will accommodate this variety of learning activities. A building plan that makes provision to house these activities in a suite of separated rooms often interferes to some extent with easy communication between the various separate, but still related, activities.

The trend of school building planning, therefore, is a search for spaces that will house a great variety of activities under conditions that make all kinds of intercommunication as direct as possible; this leads to a growing openness of plan. It is understandable that the acoustical environment of the newer schools is a problem for the architect and for the acoustical engineer.

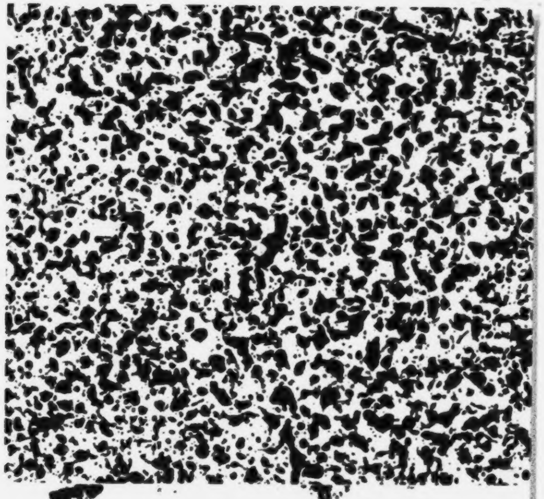
The objective of this study has been to determine the minimum acoustical separation that is necessary to allow a group or an individual to work effectively. In how noisy an environment can a teacher and a group of students work, communicate, and study without extraneous, unwanted sounds interfering? What kind of sounds are objectionable, and what is the limit of tolerable sound levels? In short, what are all the criteria for the design of an acoustical environment for classrooms which can effectively accommodate a range of activities? We recognize that special rooms for music, assembly, dining, and other activities demand different criteria.

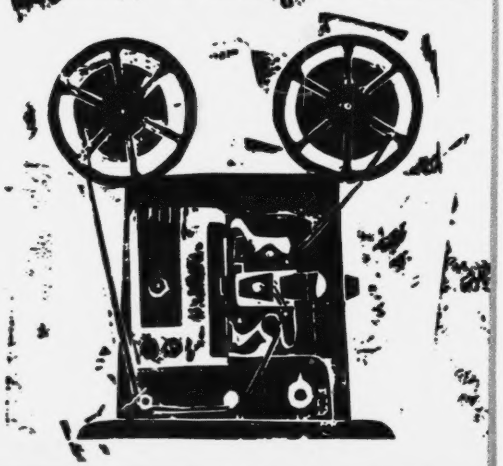
The architectural problems of educational buildings at the secondary level were the starting point for this investigation; however, our work was not limited to secondary schools but included elementary schools and two school plants at the university level. We believe that our findings deal with the effect of the acoustical environment on people generally.

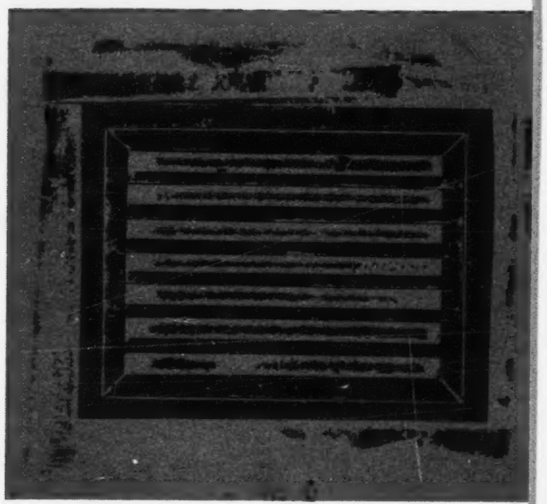
It is our hope that our study and this report will enable educators, architects, and acoustical consultants to become more conversant with the acoustical problems of the learning environment as we see them; that their necessarily cooperative efforts may be made more effective; and that the learning environment may generally be improved by increased attention to acoustical problems. We believe that the acoustics of the learning environment have, in the past, been given much less attention than they deserve.

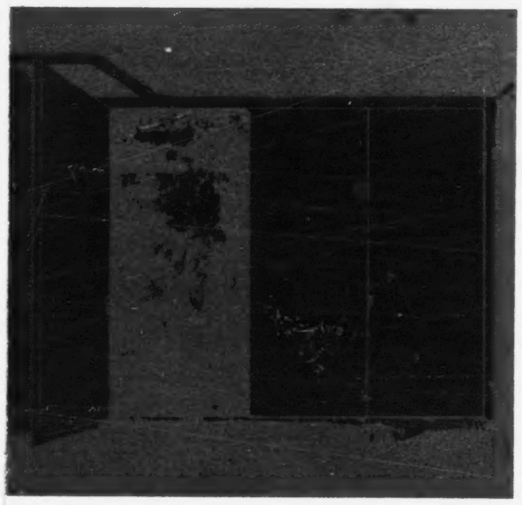
We are quite aware of the complexity of this field. Some of our findings represent our own opinions, but we have tried as far as possible to place heavy emphasis on the opinions of the users of the school plants. We are also aware of the fact that many facets of our study are not as complete as we would wish and that in the field of acoustics there remain many questions yet to be answered.

We are fortunate that Educational Facilities Laboratories has sponsored this study and report, and we appreciate the complete freedom that was given us to determine method and procedures in our work and in the presentation of our findings.









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ANALYSIS AND CONCLUSIONS

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EC	1	2	3	4			5	6	7				
	RM E6-E5	RM 7-8	RM 31B-31A	RM S6-M7	S5-S6 DOORS OPEN	STUDY AREA-M3 DOORS CLOSED	RM 46-45	RM H20-H19	B105-B106 Uncarpeted	C101-C102 Carpeted	RM 194-192		
NOISE REDUCTION													
75-150 cps	21	−5	7	19	18	21	19	14	13	10	28		19
150-300 cps	21	9	14	21	18	23	28	23	27	20	27		23
300-600 cps	27	22	22	33	21	25	33	34	36	32	37		28
600-1200 cps	33	25	24	38	21	25	35	35	43	39	45		36
1200-2400 cps	35	33	26	42	20	17	38	45	43	37	46		43
2400-4800 cps	38	36	32	44	19	14	38	47	47	40	51		46
Average 75-4800 cps	29	20	21	33	20	21	32	33	35	30	39		33
CLASS PRESENT													
Class In Session db Range	60-70	58-69	60-74	61-75	62-74	60-78	62-68	55-75	70-75	58-65	60-80		61-66
Average	65	63	67	66	69	67	64	69	72	63	73		64
Class Silent db Range	59-65	57-62	58-64	58-65	60-67	57-61	59-61	49-55	61-61	59-63	55-60		60-64
Average	62	59	62	60	63	59	60	52	61	61	53		61
Speech Interference Level	53	35	48	49	49	49	41	49	35	38	47		41
Articulation Index	.01-	.05	.01-	.01-	.01-	.01-	.01-	.01-	.01-	.01-	.01-		.01-
ROOM													
Volume Cu. Ft.	8060	7607	8100	5140	2200	9700	7560	7500	8570	8570	7597		15500
Reverberation Time (RT) Sec.	.71	1.10	1.05	.88	.62	1.07	1.04	1.17	.89	.58	.72		1.68
Optimum Reverberation Time (RT) Sec.	.66	.65	.66	.58	.44	.70	.65	.65	.67	.67	.65		.77
TEACHER OPINION POLL (%)													
Excellent	25	25	25	45	45	45	70	33	0	25	63		37
Good	65	62	58	39	39	39	27	50	17	60	28		31
Satisfactory	10	7	0	0	0	0	3	17	51	15	0		19
Acceptable	0	0	0	6	6	6	0	0	32	0	9		13
Not Acceptable	0	6	17	10*	10*	10*	0	0	0	0	0		0

*Teacher opinion poll was taken for the school as a whole—not specifying individual rooms.

2	3	4	5		6	7	8	9	10	11	12	**SW**	1		2		3				
RM South Half CLUSTER 2	RM A121-A123	RM 104-105	RM 11-12 DOOR CLOSED	RM 11-12 DOOR OPEN	RM D2-D3	RM 305-304	RM 20-19	RM B-A	RM 108-109	RM 89-88	RM 202 (B-A)		RM 304-305	RM 204-205	RM C5-C6 Uncarpeted	RM K1-H6 Carpeted	RM 118-117	RM 3-4	RM 11-12	RM 20	
10	10	17	19	19	13	29	24	16	20	10	−2		14	13	17	13	15	17	15	18	1
9	15	19	23	23	12	29	26	20	18	11	5		17	19	18	15	16	19	20	17	2
7	24	24	26	24	13	30	30	23	21	14	9		23	20	20	21	18	19	23	21	2
6	28	25	27	25	16	32	30	24	24	17	15		27	22	23	20	21	20	27	24	3
6	27	28	25	23	20	37	26	24	25	17	17		34	27	21	23	24	22	32	26	3
8	25	29	26	25	22	35	25	23	24	18	19		31	27	21	25	21	23	34	29	3
8	22	24	25	23	16	32	27	22	22	14	10		24	20	19	19	19	20	25	22	2
77-83	58-73	63-78		60-65	63-75	62-70	57-66	61-64	61-68	70-78	68-73			60-70		60-70	65-77	57-70	50-65	72-77	56-
80	64	69		63	67	65	61	62	65	74	70			61		65	71	65	59	74	5
76-80	42-49	65-68		60-65	64-66	60-65	59-59	61-62	59-64		67-69			57-63		57-60	69-69	58-62	52-68	65-65	50-
77	45	67		61	65	62	59	62	61		68			60		58	69	60	54	65	5
58	42	51		47	50	47	35	61	65	40	50			45		49	57	46	42	48	3
.01-	.02	.01-		.01	.02	.01-	.07	.01-	.01-	15	.05		.01-	01		.01-	.01-	.01-	.01	.01-	.
11160	7300	10764		8210	7450	12150	9040	7530	7985	10110	10750		6440	4560		7080	5350	8850	6590	7420	69
.73	.47	1.13		.57	.60	.63	1.05	.55	.91	live	live		1.00	.50		.65	.96	.91	.51	.71	1.
.73	.64	.71		.67	.65	.73	.68	.65	.66	.70	.71		.62	.56		.64	.59	.68	.63	.65	.6
0			8	8	0	67	0	30	12	22	22		0	0	60	60	100	0		60	1
100			77	77	33	27	82	70	38	56	33		50	50	33	33	0	9		30	5
0			8	8	39	6	9	0	38	11	6		31	31	7	7	0	64		10	3
0			7	7	17	0	9	0	12	0	11		19	19	0	0	0	27		0	
0			0*	0*	11	0	0	0	0	11	28		0*	0*	0*	0*	0	0		0	

Analyzing a survey as extensive and as complex as this is a most difficult undertaking. It is, of course, mandatory that it be done as objectively as possible. Yet there is always the danger that subjective opinions and reactions may influence any conclusions that may be expressed. It was for this reason that questionnaires were submitted to many room teachers, members of the administrative staffs, and others. Even the opinions of these people, as we soon discovered, are subject to some question because frequently the answers were influenced by private opinions and prejudices not always supported by what seemed to be the facts.

At the beginning of the survey, it was planned to ask the teacher in the specific room tested to express an opinion as to the acoustical environment. Immediately it became apparent that the question seemed to challenge the teacher to find faults, which was not the objective of the question at all. It was observed that some teachers seemed to feel that failure to enumerate a list of faults would in some way reflect upon their perceptive abilities. So this was abandoned.

Instead, the teacher opinion poll was substituted. It is believed that this teacher opinion poll is a very important aspect of this survey because it does assess the quality of the teaching environment by those who actually use it. The teachers were not unanimous in their opinions except in two schools. This poll certainly reflects prejudices, conditioning, the teacher's mood of the moment, and other factors that may be variable from teacher to teacher and from day to day. It is believed to be valuable but not infallible. Its chief value, in our opinion, is in the percentages under the various ratings rather than in the comparatively few cases where a few teachers may have called the classrooms unacceptable.

Comments under these *not acceptable* ratings ranged widely. Some criticized the rooms from the acoustical viewpoint as being "too noisy," "interference from other classrooms," "too little soundproofing," "noise of audio-visual equipment in nearby rooms is an interference," and other similar comments. But there were also such comments as "poor attitude of the students," "poor arrangement of room," "steps are dangerous," "too little storage space," "poor ventilation," and so on.

In only 22 per cent of the schools were there any *not acceptable* ratings. In these schools the *not acceptables* ranged from 6 to 28 per cent of the faculty.

The over-all measured sound reduction from one classroom area to another is termed *noise reduction* in this report. This is the amount of acoustical separation. The highest percentage of *not acceptables*, 28 per cent, was found in a school having an average noise reduction of 10 decibels. The next highest, 24 per cent, was recorded in a school with an average noise reduction of 27 decibels. Yet in the same area another school having a noise reduction of 29 decibels registered no *not acceptables*. Curiously, the lowest percentage of *not acceptables* was noted in a school having a noise reduction of 20 decibels average

In the past it has been thought that a noise reduction of 40 to 45 decibels was mandatory between classrooms. While, admittedly, the survey concentrated on "acoustically bizarre" schools, the schools included both so-called open and closed classrooms. Open classrooms are those which do not have complete closure. There may not be doors, or there may not be corridor walls of any type, there may not even be walls between classrooms. In other words, there is no substantial acoustical barrier between classroom units. The closed classroom is one completely enclosed with walls and doors in the conventional manner.

Significantly, not a single school that we tested had an average noise reduction of 40 decibels. The tests reached 39 in one school. The next highest rating was 38 decibels.

The average noise reduction in all schools surveyed was 24 decibels. The average teacher opinion poll was: *excellent*, 28 per cent; *good*, 42 ½ per cent; *satisfactory*, 18½ percent; *acceptable*, 7 ½ per cent; and *not acceptable*, 3 ½ per cent. Note that 70 ½ per cent of the faculty would rate this environment statistically as *good* to *excellent*, with 96 ½ per cent of the faculty calling it *acceptable.*

About one-third of the schools were of the open type. In these schools the average noise reduction was found to be 18 decibels. In this environment the average teacher opinion poll was: *excellent*, 23 per cent; *good*, 45 per cent; *satisfactory*, 22 per cent; *acceptable*, 6 per cent; and *not acceptable*, 4 per cent.

Note how closely the teacher opinion poll agrees, in the case of the open type school, with the poll average of all schools surveyed.

Noise Reduction

Laboratory reports of the sound insulation qualities of any type of barrier are based on the *sound transmission loss.* This is a term intended to define the contribution of the barrier itself in reducing the transmission of sound from one area to another. It does not take into consideration the area of the specific barrier. Neither does it make allowance for the effect of the acoustical environment in the listening room.

In any real situation, however, the amount of sound reduction actually experienced by a listener includes, in addition to the sound transmission loss, the effects of the area or areas of the boundary, and the acoustical environment of the listening room. Measurements which include the combined effects are termed *noise reduction* or *noise reduction factor.* It was the noise reduction which was measured in this survey, since we were primarily interested in the actual acoustical separation between teaching areas.

The measurement of the over-all sound level in one room and the subtracting from it of the over-all sound level in another room is an over-simplification which could and probably would be quite misleading. It has long been found necessary to measure the differences in levels in octave bands at least. Many measurements, particularly in laboratories, are made at 9 to 11 different frequency bands.

In this survey the field measurements were made in the 8 octave bands from 37.5 cycles per second to approximately 10,000 cps. However, since the first and eighth bands contribute practically nothing to speech frequency components, these bands were omitted from the charts reported in this survey.

Reverberation

There are a number of factors which, according to our present understanding of acoustical phenomena, may be important in assessing the acoustical suitability of any classroom.

First, the classroom should not be too reverberant. If the room is too "live" —the term, liveness, refers to a condition of excessively prolonged reflections or reverberance—there will be difficulty in understanding what is said. This is because the rate of sound decay is so slow that one or more syllables persist in the room to the extent that they are in conflict. The listener has difficulty in separating them. In a reverberant room this prolongation of the sound applies not only to the speech originating within the specific classroom, in this case the wanted sound, but it applies also to any intruding sound, whether from within the room itself or from external sources, which may be in conflict with this wanted sound. Such intruding sounds may come from heating and ventilating equipment within the room itself, or they may be sounds from neighboring rooms. Similar conflict with the wanted sound may be the scuffling of feet on a hard floor, the moving of furniture, the impact of books or their friction sounds—there are many such sources within the room.

To the extent that such sounds compete for perception, they influence and interfere with easy speech communication. Thus a "live" room—one that is excessively sound-reflective—may be termed unsatisfactory if there is difficulty in understanding speech. If there is difficulty in hearing such speech through unnecessarily high within-the-room noises, the room may be termed "noisy." If the listening environment is too reverberant the classroom may be unacceptable even without interference from other rooms.

There are many so-called optimum conditions, varying slightly in opinions expressed by different specialists in the field. The nearest to a consensus seems to be the criteria recommended by a group of prominent acousticians some years ago, acting as a technical advisory committee for the Acoustical Materials Association.

Such criteria are expressed as *periods of reverberation*. For optimum reverberation periods for speech, as recommended by the Acoustical Materials Association, varying with the volume of the room, the following mathematical formula may be used.

$$T \text{ (in seconds)} = \frac{\log_{10} V - 2.25}{2.5}$$

Where V is the room volume in cubic feet.

If the period of reverberation at 500 cps is in the vicinity of the time as found by the above formula, when the room is occupied near capacity, speaking and listening to speech should be found satisfactory, providing conflicting noise levels are not too high. Where reference is made to optimum reverberation periods in this survey, the above method has been used in establishing the optima.

It should be noted that an important qualification is the level of the conflicting noise. This, of course, is a level related to the ratio of the conflicting or background noise with reference to the wanted sound. Because of this, calibrated tape recordings were made at all schools, sampling the sound levels of the class in session in specific rooms and then asking the class to be silent in order to take tape recorder samples of the accumulated background noise.

Both recordings were converted to graphs showing the variations in level, after which the levels were averaged. Additionally, octave band analyses were taken from these recordings and were related to the averaged levels. These data are also included in this report.

Speech Interference Level

For some years now one important criterion in considering conditions for speech communication has been the *speech interference level.* (See Glossary of Terms.) The speech interference level has been proposed as a simplified method of arriving at maximum tolerable conflicting noise levels for satisfactory intelligibility. As examples: With an S.I.L. of 43 db, reliable conversation is believed to be possible at normal voice levels at a distance of some 12 feet. Where the S.I.L. is 55 db, reliable conversation is estimated to be possible at about 3 feet at normal voice levels and at 6 feet with a raised voice.

Without much doubt the speech interference level system is subject to considerable modification due to the possibility of lip-reading. It is further felt that the ability to hear binaurally may be a major factor in nullifying this as a reliable criterion. The data are included in this survey for what they may be found to be worth. We were not impressed by their apparent usefulness in this investigation, because this system did not seem to be a reliable gauge in view of our measurements of the S.I.L., the voice levels, and the distances of communication.

Articulation Index

It was felt that the ability to recognize speech components from external intruding sources could have considerable influence upon the degree of acceptability of a given classroom. At this time the *articulation index* seems to be the most reliable assessment of this situation. (See Glossary of Terms.)

The articulation index is a somewhat complex calculation involving the octave-band levels of the average voice in the five octave bands from 150 to 4800 cps. It takes into consideration the background noise level and the noise reduction separating the two classrooms. These are subtracted from the assumed normal voice levels—all in the five octave bands mentioned—and any residual levels in any of the octave bands are weighted according to the presently accepted understanding of their contributions towards speech intelligibility. The final result is the articulation index.

Based on intelligibility tests reported up to the time of this writing, where entire sentences were used, the apparent relationship between the articulation index and the intelligibility seems to be:

Articulation index = 0.06 10% of words understood
" " = 0.10 20% " " "
" " = 0.20 55% " " "
" " = 0.30 82% " " "
" " = 0.40 90% " " "

Understandably, with a low background noise and with a too-high articulation index, even where the intruding speech may emanate from a speaker with normal voice power output, speech from an adjacent room may be annoying or interfering. Where the intruding speech may be from amplified sound such as audio-visual equipment, the interference is increased. It might be mentioned in this connection that very frequently the amplifier gains are set much higher than necessary for understandability.

One such source may be an interference because it is intelligible. Paradoxically, several such sources seem to be less interfering because they compete with each other and reduce the intelligibility of any single source. As more such sources combine, as in the case of the open classrooms where the speech sounds from many classrooms may be added together, the intruding speech sounds blend together into a somewhat bland hum without easily identifiable speech components. This seems to be the reason why open classrooms have been found to be acceptable in such high percentages.

The articulation indices listed in this report are based on calculations assuming a normal, unamplified voice. The background noise used in the calculation is that measured with the class silent. The noise reduction between teaching areas is that actually measured.

Where there is a low background noise in any specific classroom, even with a relatively high noise reduction in this room's boundary, a high articulation index could be found to be an annoyance by many teachers. With high sound interception in the boundaries, the background noise levels are dependent upon heating and ventilating system noise or noise from street traffic, particularly where windows may be open. In such cases, clearly articulated speech could become an annoyance. Should such speech be amplified the annoyance may be expected to be increased.

The Apparently Important Variables

From observation during this survey, it would seem that there are several important variables which contribute to the acoustical situation in the classroom.

The first of these is the reverberant environment. Where the room is near the speech optimum, both speech and listening are comfortable, without effort necessary on the part of the speaker or listener. The sound absorption in the listening area also contributes toward increasing the noise reduction. Additionally, noises originating within the room are lower in level than they would be if the room were live and reverberant.

Sound absorption in adjacent classrooms or corridors also contributes to lower noise levels by absorbing intrusive noise which would otherwise be transmitted through the classroom boundaries.

Where the classroom is live, speech is more difficult to understand because, as mentioned before, there is difficulty in separating syllables. Further, the room noise being higher, there is more effort necessary to project speech.

The second important variable, it would seem, is that any intruding noise should be of a general character, without easily identifiable components. The levels do not seem to be too important. In this connection School 2-MW might be cited. Here the average background noise level was found to be 77 decibels, yet the teacher opinion poll found the faculty unanimous in classifying the situation as *good.* In School 3-SW the faculty assessed the conditions as *excellent* unanimously with an average background noise level of 69 decibels. The speech interference levels were, respectively, 58 and 57 decibels.

On the other hand, in the few schools, for which data are available, where there were any *not acceptable* ratings, *almost all had lower background noise levels and lower speech interference levels*

The third important variable seems to be the articulation index. This should be very low, possibly not more than 0.01 for best conditions.

A fourth variable seems to suggest an acoustically absorptive floor covering to reduce within-room noise and to contribute beneficial added sound absorption.

The fifth variable seems to be the noise reduction between teaching areas, but in view of the first four variables the actual amount of noise reduction, if above certain minima, does not seem to be too important. In view of the various factors brought to light in this survey, logic seems to indicate this conclusion and the teacher opinion poll seems to confirm it.

The sixth variable is the most complex of all and does not seem to present any easy solution. This is the human factor.

All acoustical problems, whether they involve "tuning" a concert hall, providing proper privacy in apartments, or ensuring suitable acoustical separation in office buildings, must ultimately encounter the human factor. This involves matters that cannot be classified with any precision. Critics of these environments are influenced by previous conditioning, by special hearing characteristics, by personal tastes and preferences, sometimes by prejudices and opinions that are difficult to define, even by the mood of the moment, or by other perplexing factors. Such intangibles are apparently too evanescent and too elusive to present any direct clue as to how they may be solved. It would seem that one must be reconciled to the fact that no solution can be expected to be satisfactory to everyone. A solution that would be satisfactory to most seems possible and the best that may be expected.

Views of associated acoustical investigators

We have asked three of the acoustical consultants who have worked with us in conducting studies to give us a statement summarizing their findings and opinions. The late Dr. Hardy and his associate Mr. Bonvallet analyzed seven schools and shared with us the work on one additional school. Mr. Kodaras and Mr. Hansen analyzed four schools and Messrs. Lane and Mikeska analyzed five. Although their experiences cover fewer schools than did ours, we believe their opinions to be most important and we have included them in the following paragraphs.

Mr. Mikeska offers the following summary:

"This letter is a belated answer to your request of August 2 for generalized comments on the open plan schools we tested in the EFL survey. Of course we do not have the questionnaire data, and did not analyze them in detail other than to look over the responses during the course of the work, so we are not able to state firm conclusions.

"However, I remember a few specific comments that may be helpful to you. Several students at 8-SW High School mentioned that they found it very difficult to concentrate during examinations when their own classroom is quiet and the adjacent ones are not. Also, the principal at 1-SW High School indicated that he is much more pleased with their new classroom building which has a conventional double loaded corridor arrangement with doors on the classrooms. The doors normally stay open, but they can be closed when greater privacy is needed. The new building also has an air-conditioned audio-visual room on which the doors always stay closed, thus fulfilling an important need for the school which was not provided for in the original open plan section of the school.

"In general, I suspect that many of the teachers' and administrators' reactions are strongly influenced by factors other than acoustical, such as lighting, room arrangement, and general adequacy of the facilities for the teaching needs involved.

"We are, of course, very interested in the results of your study."

Mr. Kodaras writes as follows:

"Three aspects seem to be involved:

a) People: Students, Teachers and Administration.

b) Idealism: Why do we send children to school?

c) Economics: How much does it cost to make a school quiet and do we need it?

"In our conversations with the faculty, students and principals we found that the weighting assigned to the importance of acoustics varied from (a) not important—noise from adjacent classroom, to (b) very important—distractions divert the students. We believe that the students generally are rather indifferent to noise of the type and magnitude we measured and are conscious of this noise as an intrusion when the teachers themselves make an unfavorable comment about it. The administrators are too busy with program development and teacher orientation to be concerned about the brand of acoustics we are concerned about—cross-talk—and rightly so. One principal remarked that the efficient process of education is predicated on the subject presentation and student interest. The above conditions must be met rightfully in order for student intellectual growth. I would agree with this in certain respects.

"However, other administrators firmly believe that the efficiency of the proper environment and self-serving functions of the school are just as important, acoustics being part of the environment.

"We know of a school system that was guided by the architect who in turn was guided by the rule of thumb: 'a penny saved is a dollar earned,' forgetting the rule of pinky: 'penny wise—dollar foolish;' and erected lightweight aggregate block, integrally colored, in these schools. Complaints on the part of teachers provoked the school to have us test and evaluate the TL and recommend. The TL ranged from 22 db to 28 db. We asked the school superintendent if we could distribute the questionnaire to the faculty but were refused only because at that time there existed a potential lawsuit between school and architect. We do not blame the architect in this case; he was the unfortunate listener to the manufacturer's claims of 38 db to 44 db.

"We measured NC 45 in certain classrooms—students unperturbed. Yet in one school, students were annoyed because of the operation of a tractor adjacent to the school building. This might be attributed to the fact that the tractor noise was an intrusion while the diffuser or air induction units were considered part of the environment.

"To sum it up: We would propose that the significant scholastic aspects are predominated by subject matter, presentation, students' inclinations and classmates. Students can be distracted by sounds outside their own classroom and for some this may be a welcome change of pace. However, it is a question of serving the best interests of the students, and the best interests in this case would be no distractions. Therefore, we believe good noise reduction between classrooms is an essential item in school design."

The late Dr. Howard C. Hardy said to us after completing the analysis of some of the schools included in this report:

"You asked me some time ago to give you our over-all impressions of our part of the acoustical survey of educational facilities. We discussed our reactions here among ourselves in great detail, trying to make up some generalizations which would be of use to you. We found it very difficult to discover any common connecting thread among the different geometries we studied. It would appear that it is very possible to have much wider open construction than has ordinarily been supported by acoustical engineers. The reason for this appears to be that the rooms are used in an entirely different way from the conventional classroom where the open construction would be practically impossible. However, we seem to sense that some of the teachers feel that they are losing something by not having wall separation, even though their answers to the questions submitted would not indicate this. Whether this is just a reaction to change, we do not know. In one classroom where there were no doors, they said they had no acoustical interference, which our own observations indicated not to be quite correct. However, the answer to another question, on how to improve the room, was that they would put doors on it. There might be reasons, other than acoustical, for having doors.

"It would appear that the wide-open construction is much more acceptable in grade school than in high school operation...."

We are not in agreement with this statement. Our records indicate to us that there was more objection in the elementary schools to open construction than in the high schools because of conflicts in noisy activities such as group recitation, singing, and similar procedures more characteristic of the elementary grades.

Dr. Hardy continues: "...The acoustical privacy requirements of college classrooms appear to be even more severe. This is probably because there is more likelihood that the classes will be organized into a formal lecture arrangement in the more advanced courses. The informality of the present trend in teaching the grade schools is, I believe, less likely to be carried into the higher grades and secondary school teaching schemes. Where the lecturer and the hearer are separated by 20 feet or more, the acoustical interference from adjoining spaces is much more of a problem. Hindsightwise, I think we should have obtained more data in regard to the distance between the teacher and the students.

"Another conclusion we come to is that the stereotype of the old-fashioned classroom is rapidly disappearing, and there undoubtedly will be a large variety of classroom arrangements, and it will be unlikely that a single new standard classroom arrangement will evolve. There will be considerable choice, therefore, among school administrators on how they will make their classroom layout, depending somewhat on their teaching techniques and the procedures which they have previously developed. I think this is a very stimulating situation and Educational Facilities Laboratories is to be complimented on the progressive movement which it has stimulated."

We do not find ourselves in complete agreement regarding the opinions expressed by our consultants but we believe their opinions to be thoughtful.

General observations

Certain kinds of sounds must be considered not only noise problems but in addition they have an effect which is somewhat psychological. In School 6-MW classrooms were served by a long, glazed, single loaded corridor with two entrances, one at each extremity. The floor was asphalt tile on concrete and very live acoustically. Classrooms were separated from the corridor by a low bank of lockers and the space from the top of the lockers to the ceiling was open; those who walked in the corridor could be seen from the classrooms as well as heard.

When students in any classroom heard the door open at the end of the corridor and then approaching footsteps, the effect was almost hypnotic; it was impossible not to wait for the person to pass and look to see who it was. If the approaching person turned into another classroom the remaining classrooms not passed by the person in the corridor were filled with disappointed listeners.

The same effect was produced in the story of the pianist in the upstairs apartment, who taunted the pianist in the downstairs apartment by coming home late at night and striking a mighty minor chord; the downstairs pianist could not resume sleep until he arose from his bed and struck the major chord.

The acoustical environment of a building space is a facet of architectural design in the hands of a sensitive architect. Some interior spaces may need to be muffled and dead; others may need to be live and reverberant. The ability of the architect and his acoustical consultant to use these attributes of space and volume may enrich the design of school buildings.

A teacher criticism that occurred with great frequency was the disturbance created by audio-visual equipment in neighboring classrooms. Although a satisfactory solution is quite difficult to find, the problem is real. Another problem so often criticized by teachers is the noise of mechanical equipment; this problem, however, can easily be solved by careful acoustical design and by close supervision during construction.

The very nature of our survey, and the objectives of the survey, provided us with a tremendous store of teacher opinion on acoustics. Quite often teachers would become hypersensitive about acoustical problems, particularly if the acoustical environment of a project fell short of their expectations. We had to judge when the criticisms were unrealistic. In some cases no acoustical environment would have escaped criticism. Open planning really does offer a solution to certain kinds of educational problems, but open planning also presents problems, which when not properly solved cause serious inconveniences to occupants.

Architects have shown for many years a predilection for open planning, where the barriers that separate one building space from another are slowly lessening in importance. This first showed itself in residences and now in schools as well as in many other building types. Most of us architects believe that this predilection is the mark of a contemporary thinker, and so, open planning is good.

From the information gained in making the survey, many teachers do not value an open plan for itself; this is often because open plans are inadequately designed acoustically and therefore many teachers think that open plans are unavoidably bad, acoustically. We now know that this need not be so. In one case, in School 1-SW, we found a teacher who spoke favorably and even enthusiastically about openness. However, teachers usually value the open plan when an educational requirement is best solved by the open plan. One pertinent fact observed by the investigators is that acoustical engineering skill has occasionally been directed to the problems of the acoustics of the auditorium and the music room and not at all to the acoustics of the classroom.

Architects usually seem to like lots of glass in their designs; in almost every one of the many cases that came to our attention, where glass was used, teachers have found reason to criticize its generous use. They have commented, not necessarily on a valid basis, that it is the pathway for acoustical leaks and in addition presents serious problems in sun control. In only one school, 4-EC, was delight expressed by the teachers because of the views afforded through the glass.

As mentioned previously, it is felt that the teacher opinion poll, while a valuable guide, is not infallible. But it does present some clues as to probable advisable environment.

Where ratings of *excellent* were in the majority, the noise reductions ranged from 19 to 39 decibels. The speech interference levels ranged from 41 to 57 decibels, but the articulation indices were all below 0.01. Most of these rooms were at or near optimum reverberation periods. In one case the room was found to be very reverberant, but the noise reduction was relatively high at 32 decibels. There was also one school with a very reverberant classroom and a noise reduction of only 19 decibels.

This latter may be the proverbial exception to prove the rule. Generally, however, the indications are that (1) a very low articulation index is desirable, (2) if there is a low noise reduction, it should be coupled with optimum reverberation periods in the classroom, and (3) live reverberant classroom conditions require much higher noise reductions. The speech interference levels do not seem significant. The schools included in this category are located in the Southwest, the Midwest, and the East Coast.

In those schools where the majority ratings were *good*, the noise reductions were from 8 to 38 decibels. The speech interference levels ranged from 34 to 61 decibels, but in 69 per cent of the cases the articulation indices were 0.01 or less—actually most of these were below 0.01. In one case the noise reduction was 14 decibels, with a speech interference level of 40 decibels and an articulation index of 0.15. The room environment was highly reverberant. There were, however, some *not acceptable* ratings.

In another case the noise reduction was 20 decibels, with a speech interference level of 35 decibels, a highly reverberant classroom environment, and an articulation index of 0.05. In another school with a noise reduction of 21 decibels, a speech interference level of 48 decibels, a reverberant classroom environment but with an articulation index below 0.01, there were some *not acceptable* appraisals.

Otherwise, where the room environments were reverberant, the noise reductions were substantially higher and the articulation indices were quite low—0.01 or lower except in one school where the A.I. was 0.03 and in another with an A.I. of 0.07.

Schools in this group were from the Southwest, the Midwest, the East Coast, and the West Coast.

Significantly, one school on the East Coast had large areas both uncarpeted and carpeted. In the uncarpeted section the majority of the opinions rated the rooms as *satisfactory*, but in the carpeted portion the teacher opinion was changed to a majority assessing the rooms as *good*. In the first case 83 per cent of the faculty were divided between *acceptable* and *satisfactory*, and in the second case 85 per cent rated the rooms *good* to *excellent*.

This is in agreement with School 2-SW, also carpeted, where the faculty were 93 per cent in adjudging the rooms *good* to *excellent*.

Of the schools surveyed 35 per cent were of the open type and 65 per cent were closed. In the teacher opinion poll 23 per cent of the open schools were classed by the majority as *excellent*, with 19 per cent of the closed schools so rated. Where the majority rating was divided between *excellent* and *good*, 77 per cent of the open schools were so rated, with 86 per cent of the closed schools in the same category. Relative to the *not acceptable* ratings: 23 per cent of the open and 24 per cent of the closed schools were so evaluated.

This seems to indicate that there is no special significance as to whether the schools are of the open or closed types. Actually, during the survey we found that in a great majority of the closed schools the doors of most classrooms were left open during school sessions. This, of course, placed these schools acoustically in the somewhat open class as far as actual practice was concerned. Certainly intercommunication between classrooms was materially increased. One school in the Southwest had closed classrooms, but the corridor wall had large areas in jalousie type openings which were kept substantially open.

Investigation disclosed that open doors were intended to improve heating or ventilation, in some cases, even with forced air heating and ventilation. In other cases there seemed to be no apparent reason for opening the doors except that the teachers preferred it. Many teachers interviewed in the open type schools stated that they liked to hear the activities in the school, that they liked to feel that they were a part of the entire school activity. This may explain why many of the teachers in the closed schools opened their rooms.

There are some interesting aspects to a study of those schools which had some *not acceptable* ratings. In the open schools all of these had noise reduction of 16 decibels or less. Two of these had highly reverberant room environments, substantially above optimum reverberation periods, and articulation indices of 0.15 and 0.05. One had optimum environment and an articulation index of 0.02. The highest percentage of objection, however, was in the school with a 10 decibel noise reduction and an articulation index of 0.05 combined with a very live classroom environment.

In the closed schools where there were *not acceptable* appraisals, the noise reductions ranged from 20 to 33 decibels. The articulation indices were less than 0.01 with one exception which was 0.05. All of these schools, however, had very reverberant classrooms.

A comparison of the averages may be of some interest.

							Teacher Opinion Poll				
Type	Aver. NR	CIS	CS	SIL	A I	Class Room	Exc.	Good	Satis.	Acc.	Not Acc.
Closed	28	66	60	45	.008	live	31	41	16½	8½	3
Open	18	67	57	49	.025	med.	23	45	22	6	4
Both	24	66	59	47	.014	live	28	42½	18½	7½	3½

(All levels in decibels. Teacher Opinion Poll in percentages.)

NR: Noise Reduction
CIS: Class in Session
CS: Class Silent
SIL: Speech Interference Level
AI: Articulation Index

In almost all of the schools surveyed, even where the noise reductions were comparatively high, there were objections raised to the interference from audio-visual equipment operating in nearby rooms. The objections were about equal in both open and closed schools, and seemed similar whether the noise reduction was very high or very low. In most cases it is believed to interfere during those times when similar equipment was not operating in the listening room. As mentioned before, almost always such equipment is operated at levels much higher than necessary. Many administrators and teachers say they can adjust to the situation.

Providing special rooms for this type of teaching seems to be a better and more permanent solution.

Generally, the noise of heating and ventilating equipment was found to be far above acceptable levels. Where there was higher noise reduction between classrooms, the objections seemed to be stronger. This is logical, of course, because more noise from school activities would mask the equipment noise. But in several cases, even noise from other activities was insufficient to prevent air-moving equipment from interfering.

It might be observed that in few of the schools visited was there any evidence of the use of competent acoustical assistance in planning the classrooms or classroom buildings. In some cases the acoustical materials were in the wrong locations to be effective. In other cases materials intended to be sound absorptive were not substantially so. Other acoustical complications were caused by shape faults.

This also holds true of band, orchestra, and choral rooms. Few gymnasiums or multi-use rooms received competent acoustical attention.

It is our opinion, and it can be substantiated, that careful acoustical planning is mandatory in connection with music rooms, multi-use rooms, gymnasiums, classrooms, and other rooms in the average school plant. Unfortunately, many designers seem unaware of this fact. In a few cases we did find that auditoriums had been given specialized attention, but even these were in the minority.

It seems evident from what has been seen in this survey that material improvement in schools can be realized if necessary attention is given to the acoustical aspect.

In a classroom, surrounded by partitions and thus separated acoustically from adjacent spaces, acoustical criteria can be stated in positive terms; in our opinion, there is no doubt about what ingredients are necessary for optimum conditions in a classroom. These are: (1) a high amount of acoustical separation between classrooms; (2) an extremely low articulation index; and (3) an optimum or near optimum reverberant condition in the room itself. In stating acoustical criteria for open spaces, we find it necessary to deal with unwanted sound which, since we cannot exclude it, we must regard as a condition which tends to reduce the total optimum acoustical environment.

Relative to classrooms, this survey seems to indicate to us: (1) *Classrooms are less satisfactory where there is a relatively high noise reduction coupled with a high articulation index and a reverberant environment.* (2) *Classrooms are less satisfactory with high reverberation periods or high articulation indices, even with relatively high noise reduction.* (3) *Generally, where a classroom is live acoustically, higher noise reductions do not overcome objections. Conversely, where the classroom is near optimum reverberation environment, lower noise reduction is acceptable. Lower noise reduction also seems acceptable with a low articulation index, but the classroom should not be live acoustically.*

All of the above are confirmed by a careful study of the results of this survey. Additionally, it was found that a high articulation index coupled with a low noise reduction brings objection. In this same vein the lower the noise reduction the more important are the articulation index and optimum room reverberation environment. The reverberant room can be tolerated better with high noise reduction, but a low articulation index seems to be advisable also in this case.

One of the somewhat surprising aspects of this survey is that relatively high background noise levels do not seem to be objectionable, if the character of the noise is somewhat bland and undefinable as to content. By this is meant an accumulation of noise which may resemble a somewhat continuous sound of activity or intermixed, unrecognizable speech sounds, a subdued buzz or hum. It should be somewhat broad in its frequency components and without pronounced and abrupt changes in intensity level. A loud, penetrating voice with clear enunciation so that words and sentences can be understood materially reduces the acceptability. At the same time, without this high level masking sound, even a soft voice which is clearly understandable becomes an interference.

The original objective of this survey was to determine, if possible, the fundamental acoustical problems arising from the new demands in school design imposed by a variety of new teaching methods. A further objective was to determine whether such problems could be solved.

Because the change in educational methods is so great and subject to so many variations, coupled with the fact that many aspects are experimental and thus subject to possible further modification, extreme flexibility in arrangement seems to be a mandatory requirement in classroom buildings. It has been suggested that possibly the ideal school plant for this purpose might be a substantially uninterrupted expanse of floor and ceiling which could be divided and subdivided with some type of portable partition in any arrangement desired. This, of course, destroys the conventional concept of a classroom building consisting of a collection of partitioned, rectangular classrooms.

In our opinion the actual listening environment—the periods of reverberation with, perhaps, a low articulation index—is more important than high noise reduction between classrooms.

Higher noise reductions than the minima cited above could be provided if desired. But the not excessively reverberant listening space and the low intelligibility provided by a low articulation index are still recommended.

Acoustically absorptive floor coverings seem to add desirable acoustical improvement because they reduce traffic noise, the scuffling of feet, the scraping of furniture, and other floor-created noises. Apparently, from our interviews, such floor coverings bring about definite economies in maintenance costs as well.

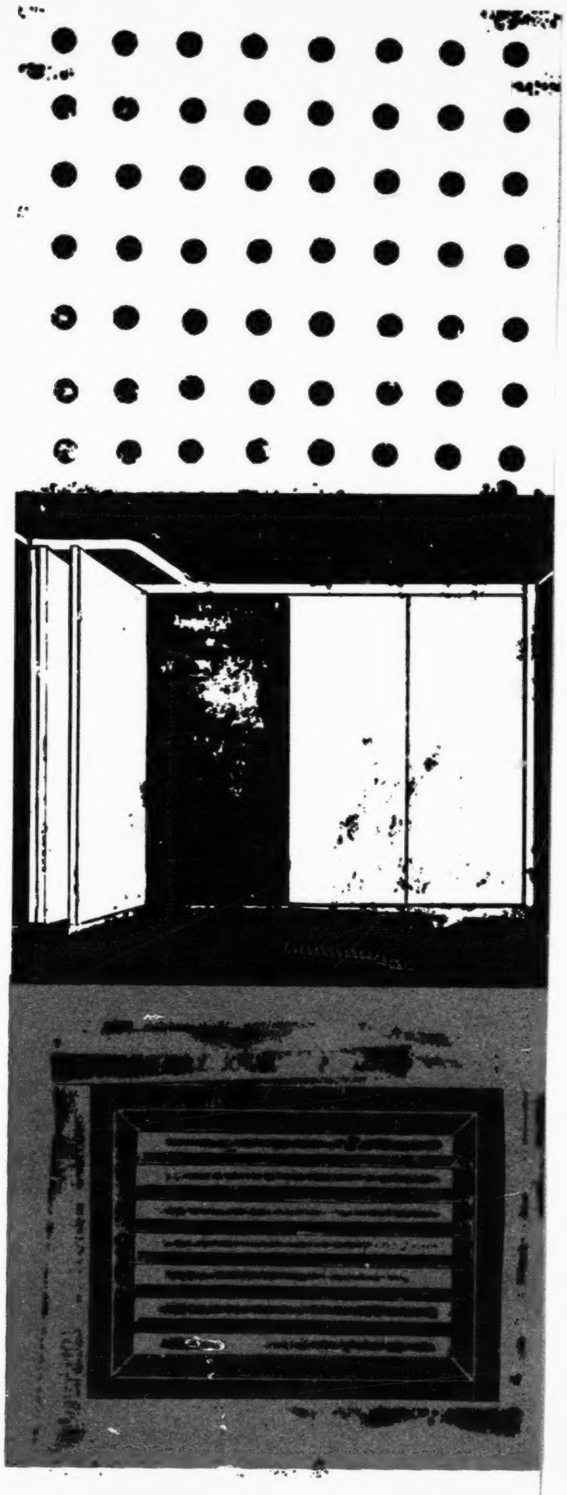
School 2-SW in this survey is carpeted. In our opinion it fully meets all requirements for suitable teaching and learning environment as well as providing facilities for extreme flexibility.

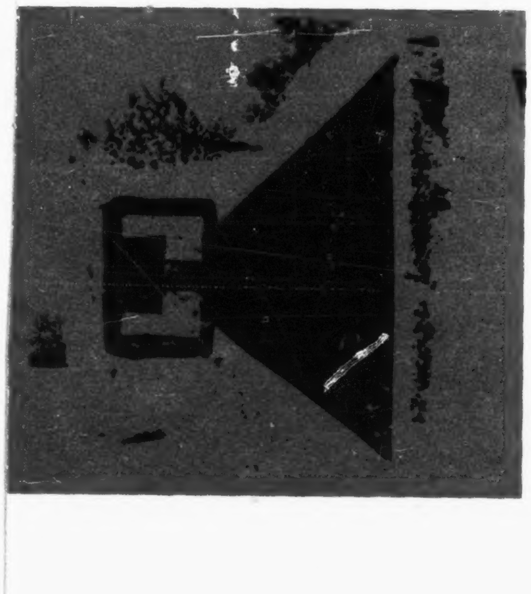
While making this survey we encountered objections to noise from many special purpose rooms such as band rooms and gymnasiums. This is completely avoidable by providing sufficient sound insulation around such rooms and by locating them suitably. In all such cases the interference could have been anticipated. Many of the transmission paths of such sounds were clearly visible.

Even audio-visual instruction can be made acceptable by careful attention to the sound level. Alternatively, of course, special rooms for this purpose can be provided, or if this is not desired earphones can be used.

In some of the elementary schools visited there were also objections because of singing and other relatively loud activities in nearby rooms. It would seem that higher sound interception is advisable in the lower grades if the teaching personnel cannot or will not coordinate their activities of this nature so that they take place simultaneously. It must be understood that such objections were made in schools where the listening environment was quite reverberant and the noise reduction relatively low.

We wish to give great emphasis to our belief that this new type of building is completely reasonable and practicable in view of this survey and of a careful study of its data. We are of the opinion that if a school should be built with noise reductions between classroom areas of 18 to 20 decibels, with the classroom environments at or near optimum reverberation periods, and articulation indices of 0.01 or less, such a building would be completely acceptable for teaching and learning and would provide the vital flexibility required.





4

METHOD AND PROCEDURE

At the beginning of this study it was agreed that the highest importance would be accorded to the opinions of teachers, administrators, and students who were occupying and using the school plants that were analyzed. These opinions, then, are the most important basis for the findings of this report.

There are obvious problems which arise from this approach. None of those questioned can be considered expert in the field of acoustics, nor can they be expected to be unusually perceptive about the environment in which they work. The opinions of teachers in a new plant, where the newness is a refreshing novelty, cannot be directly compared to the opinions of teachers in an old school. Teachers react differently on an overcast, cold winter day from the way they do on a sunny spring day; there is a difference in attitude at the beginning of a term, at the middle of the term, and in the last week of school. We recognize these uncertainties as problems; yet the responses of those contacted in the field by us presented a pattern which allowed us to draw conclusions with some confidence. In drawing conclusions, we have subordinated our personal opinions so far as possible.

In order to invite participation by the users of a school, we have six different questionnaire forms by which to record these opinions. In general we formulated our questions so as to emphasize an interest in the acoustical environment, but we also included questions which were indirectly or distantly related to acoustical matters in order that an exaggeratedly critical attitude towards acoustical problems alone would not build up in the person who was filling out the questionnaire.

We directed our questionnaires primarily towards teachers, students, and school administrators, since we are primarily interested in the classroom environment. Because we visited a great many schools and talked to a considerable number of people, we hoped to secure some additional dividends, if possible. Therefore we included a questionnaire for teachers of music, which is *Music*, Form 4. It was hoped that this would provide data that would assist us in formulating more definitive criteria for the design of rooms in which various forms of music were taught. Similarly *Multi-Use*, Form 5, was included to explore the experience of all those teachers who directed or supervised work or activities in that nationwide phenomena of the contemporary plant, the multi-use room. We viewed the multi-use room as a space which was used for dining and which was equipped with a stage or platform to allow the same room to be used for lectures, debates, audio-visual programs, musical performances, and dramatic work. This problem is of interest to all educators, architects, and acoustical engineers because of what seem to be conflicting criteria for the different uses.

A comment on the use of each form in making the field survey follows:

Teacher, Form 1

This form was given to from six to ten teachers in each school visited. Each teacher was told that we were including this school in a nationwide study as an educational facility; we neither emphasized nor concealed our interest in the acoustical environment of their specific rooms. We usually told them that the completed form would be seen only by us, that it would not be individually publicized nor distributed to others in the school system. Teachers were given the form, offered a brief explanation, and asked to fill it out immediately if possible and then return it promptly to one of the two investigators. We did not encourage teachers to ponder their answers, nor to confer with other teachers in answering questions. We were surreptitious about only one point on the form: under (a), fourth line, we entered our own estimate of the teacher's age, whenever possible. We soon became expert in this phase of the procedure.

Student, Form 2

In each room where the teacher was asked to fill out the questionnaire, Form 1, we requested this same teacher to choose three or four students and ask them to complete the Form 2 questionnaire. We specifically requested that no selection of students be made on the basis of scholastic aptitude, but rather to choose students on the basis of location of seat or desk in the room. We suggested that generally students be chosen who were seated on a line drawn across the room, from one corner to the corner diagonally opposite, to eliminate the possibility that students might be centered in a position where acoustic conditions were not typical. Since we made a recording of the class, when silent, to measure intruding background noises, we requested that students use this period of silence to fill out their questionnaires so that they would all be done at the same time. Student questionnaires were useful in providing additional information, although we did not generally expect a sophisticated response. We informed the whole class, including the selected students, that we were making a nationwide study of school buildings.

Administrator, Form 3

Generally, we selected the principal of the school tested to fill out this form, and if possible we also asked the vice-principal, dean of students, or some other person in an administrative capacity. It was our intent to secure greater depth and breadth of information about the school by asking a person who had a day-to-day contact with the teachers and who could be expected to have some objective experience in handling any problems that the school plant presented to the users. This form was handed to the administrator or administrators in the morning of the day of our testing, and we requested that the completed form be returned to us later in the day at their convenience. The administrator was told that we were making a nationwide survey on school facilities, with an emphasis on the acoustical environment.

Music, Form 4

The answers to this form were not significant to the primary objective of the survey. It was hoped that information would be revealed that would add to the general knowledge about the design of rooms specifically for the teaching of the various forms of music. It was further hoped that their comments, when correlated with our findings resulting from an analysis of the specific rooms, would be revealing. We attempted to secure completed Form 4's from every music teacher in each of the respective schools. The information secured was not deemed sufficiently conclusive to deserve presentation.

Multi-Use, Form 5

Multi-use rooms are defined for our purposes as rooms approximately 2,000 square feet or more in size which serve a variety of uses such as dining, assembly, lectures, debates, lectures or demonstrations using audio-visual equipment, musicals, dances, recreation, and the multitude of other uses generally given to this kind of room. For an architect, and for an acoustical engineer, it is virtually impossible to design a room which is acoustically suitable for this variety of use, where acoustical criteria are in conflict. It was hoped that the answers to this questionnaire would shed some light in this difficult field. We concluded with regret, after our field work was completed, that we found out very little of value.

Teacher Opinion Poll, Form 6

This was probably the most useful of all the questionnaire forms and was the most difficult to handle from our standpoint.

We attempted to solicit opinions from approximately half of the total number of teachers in any one school. Most of these teachers were only remotely aware that a survey was being conducted in other parts of the school, and we often had no personal contact with a majority of those questioned. In order to secure responses that were direct, open, and immediate, we generally made use of a secretary who was personally known to all teachers to minimize the problem of introductions and explanations. The secretary was requested to read the question at the top of the form and to note down the answer; the secretary was asked to shield the form from the view of the one who was questioned, so that her answer would not be conditioned by previous answers. She was asked to explain that this was a nationwide survey of school plant facilities and to attempt to secure general answers regarding the school as an educational facility. If the teacher seemed at a complete loss for an answer we suggested that the secretary inform the teacher who was being questioned that the question related generally to the acoustical environment.

It was our plan to secure comments that indicated whether or not the teacher could teach well in the facility. We assumed that if the acoustics were unacceptable, there might be other compensating factors in the environment that would influence the answer, and in such a case, work could be performed under acoustical conditions that might be somewhat adverse. In short, we wanted a measure of the part that acoustics played in the *total* environment.

We found that most of the teachers questioned had some inkling of our interest in the acoustical conditions, and we believe that the poll was *somewhat* weighted in the direction of a response which recognized the general purpose of the survey.

The poll was circulated among teachers who were teaching academic subjects. The secretary was instructed not to question teachers of industrial art, home economics, arts and crafts, and other subjects where the requirements of the acoustical environment would be somewhat specialized.

A criticism has been directed toward the rating scale of this *Teacher Opinion Poll*, Form 6 which starts at *excellent* and steps down to *good*, *satisfactory*, *acceptable*, and *not acceptable*. The criticism arose because of the five ratings, four were favorable and only one was negative or unfavorable, which disposed the one being questioned to a favorable answer. Our belief is that the environment is acceptable or not acceptable. If it was not acceptable then we instructed the secretary to ask why, and to note the answer under "Comment." But we believe that an environment may be acceptable in varying degrees.

The results of this questionnaire have been given considerable weight by us.

Thirty-seven schools were visited and analyzed in compiling the data on which this survey is based. Twenty-two of these were visited by Messrs. Reid and Fitzroy. Because of distances and time, we made use of three teams of consultants—Texas Research Associates, represented by Messrs. Lane and Mikeska; the late Dr. Howard C. Hardy of Chicago, with his associate, Mr. George L. Bonvallet; and Mr. Michael Kodaras of New York, together with his associate, Mr. Robert A. Hansen, for whose work efforts and interest we are greatly indebted. Their work was carefully correlated and methods were standardized to assure conformity of results.

Because of the objectives of the report, to secure data on buildings where a relatively open plan was used, we sought to study a number of "acoustically bizarre" school buildings. In order to provide balance and a wide range of acoustical environments, a great many of these school buildings were quite conventional in the degree of acoustical separation provided between classrooms. As is increasingly common today, many of the schools made use of various kinds of folding partitions, and a wide variety of partition and door details. We made no attempt at all to measure the effectiveness of the various products or systems. Our interest was solely in the environment.

We at first suspected that different geographical areas of the United States would be conditioned by prevailing practices and would therefore have different criteria for assessing the acceptability of the acoustical environment. So we chose schools in New England, in the middle Atlantic seaboard, in the extreme southeast corner of the country, in Texas and Oklahoma, in the Great Lakes area, and in California, both southern and northern. As far as possible, we attempted to make our analysis of the different schools during the middle of the school year, when routines were established and conditions typical.

Everything cannot proceed, however, exactly according to plan. We analyzed two schools which were identical in design and construction, one in the early spring and the other during the last few days of the school term. The one examined during the early spring produced results that were generally in accord with expectations; the other school, which was tested on the next to the last day of the school term, produced a teacher opinion poll which was surprising in the extent of unfavorable opinions offered by the teachers.

Architects all over the United States were asked to submit plans of schools that had been judged suitable subjects for analysis, either from our knowledge or at the suggestion of Educational Facilities Laboratories. The schools finally chosen were selected only after a painstaking study of plans and reports from the field.

For obvious reasons, we will not identify the individual schools that we have tested. We have therefore devised an identification code which consists of a numeral and two letters.

Field Tests

The field tests included actual measurements of the noise reduction between rooms, taken at the site, plus calibrated tape recordings of the sound levels on both sides of the partitions measured. The latter were resolved in the laboratory.

Calibrated tape recordings were also taken of the sound levels with the class in normal session and with the class present but silent. In those cases where noise levels of equipment in operation were taken in unoccupied classrooms, most of the data were actually measured in the field after all classes were dismissed. Some of this information was tape-recorded.

TEACHER

School:

Room:

Date: Time of day:

Name of teacher:

(a)

Subject taught: Age group of students:

Where did you teach before? What university did you attend?

How long have you taught in this room? How many hours per day do you teach? How many students are in this class?

Is there a difference, acoustically, when activities of students vary from recitation, to conference, to study? Explain:

Do you believe this room to be crowded?

Is it hard for you to speak normally and make yourself understood by everyone?

Is it hard for you to understand the speech of students or others in the room?

Does the room seem noisy?

What kind of noises in the room bother you?

Do you ever leave the corridor door open?

Do noises from neighbors interfere with your work?

What Kind?	Radio	TV
	Record player	Work
	Speech	

Can you hear noises from mechanical equipment of building?

Do you like the acoustical environment of this room?

If you had to do it over again, how would you change it?

What improvement of any kind does this room most need?

Comments:

FORM 1

STUDENT

School:

Room:

Date: Time of day:

Name of student:

Subject taught:

Can you easily hear the words of your instructor?

Do you have any trouble making yourself heard by the instructor?

Generally, is there too much noise in this room?

If so, what kind of noise?

Can you work easily in spite of the noise?

Generally, do you like this room?

If not, what don't you like about it?

Is this room too quiet?

Are there too many people in this room?

In other words, is it crowded?

What improvement of any kind does this room most need?

FORM 2

ADMINISTRATOR

School:

Room:

Date: Time of day:

Name of administrator:

Title of administrator:

What is the single improvement most needed in this school?

Has there been any critical comment from your teaching staff about acoustical conditions in this school?

Has there been any critical comment from teacher or staff regarding the room or rooms tested?

What is your own opinion of the acoustical environment in this school?

FORM 3

MUSIC

School:

Room:

Date: Time of day:

Name of teacher: (a)

Subject taught:

Is the room satisfactory for a large band?
How large?

Is the room satisfactory for a large orchestra?
How many?

Is the room satisfactory for a large choral group?
How many?

Is there interference from sounds outside the room?
What kind of sounds?

Is there interference from sounds inside the room?
What kind of sounds?

Do you need to perceive accurately the separate sounds of instruments (voices) in group music?

What improvement of any kind does this room most need?

Comments:

FORM 4

MULTI-USE

Source of information:

What is the seating capacity of the room for assembly?

What is the seating capacity of the room for dining?

How many are in the room now?

Is the room comfortable from a noise standpoint when groups are eating?

Are hearing conditions good when music is performed for an audience?
What kind of music?

Is speech generally clearly understandable when the room is:
(a) nearly empty
(b) filled to half capacity
(c) at full capacity

Do you need amplification (sound reinforcement) in room?

Is sound of mechanical equipment perceptible in room?

Is there other sound interference?

What improvement of any kind does this room most need?

Comments:

FORM 5

School

Location

Date

For the faculty:

How do you rate this school building with regard to teaching and learning?

Excellent

Good

Satisfactory

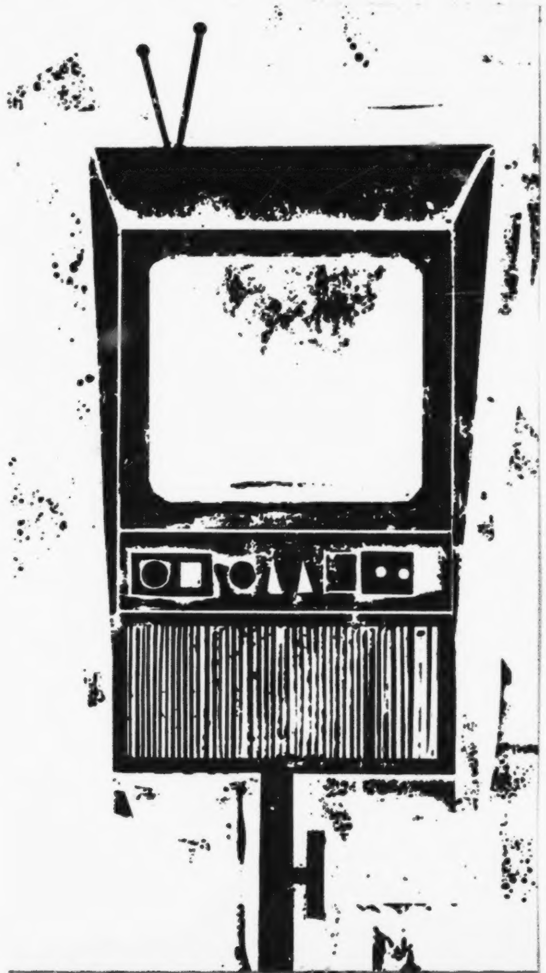
Acceptable

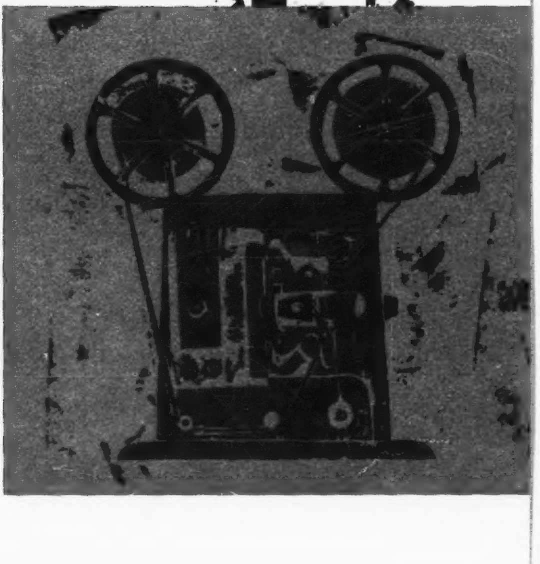
Not acceptable

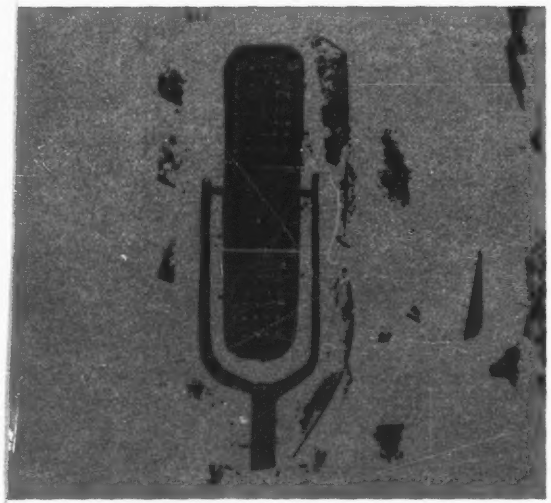
If any teachers rate the building as "not acceptable" please list below a brief comment explaining the reason or reasons for this rating; also note subject taught by teacher choosing this rating.

Comment:

FORM 6





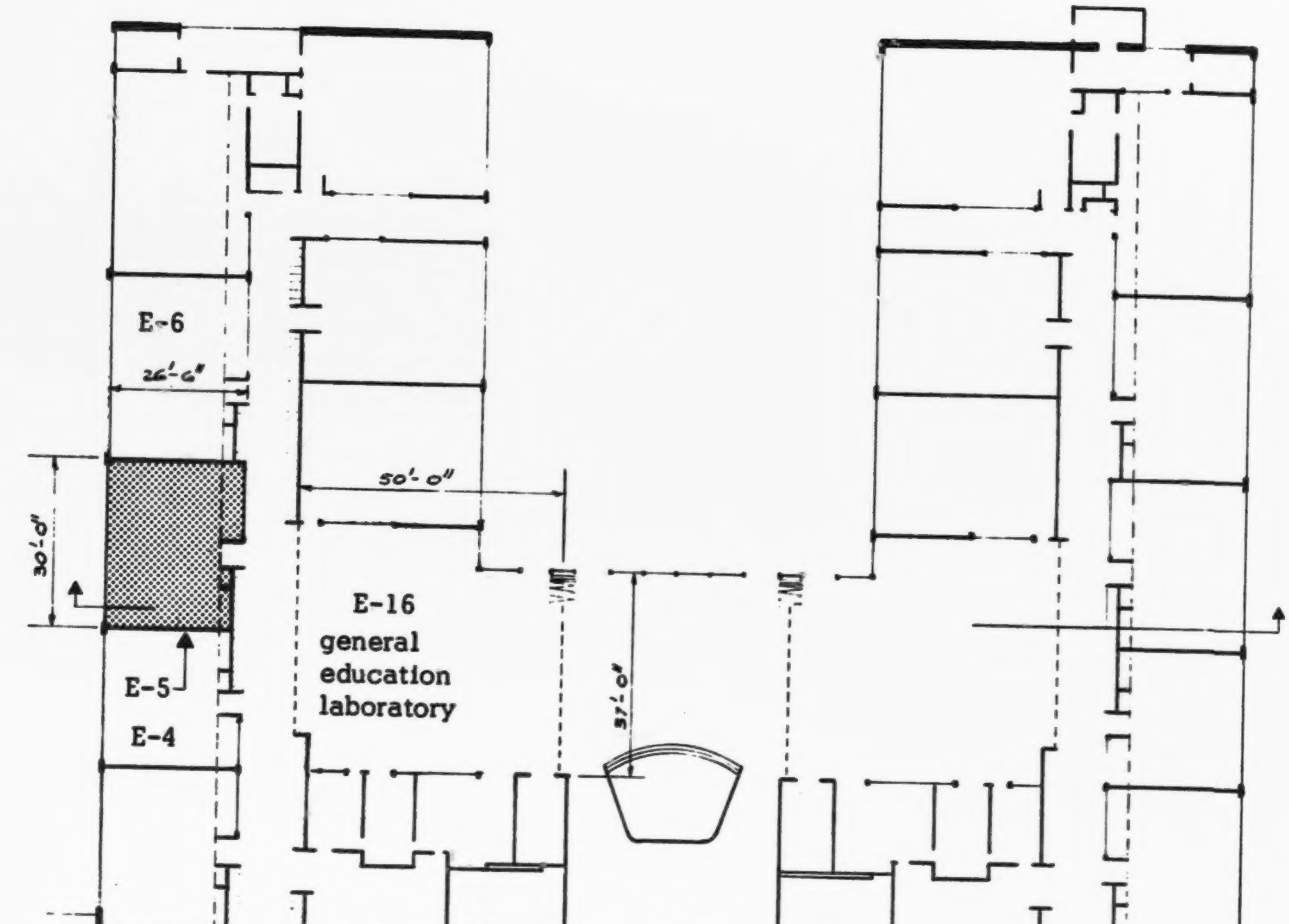


5

DATA AND EVALUATION

SCHOOL
1
EC

The use of television as a part of the instructional program has strongly influenced the planning of this high school. Two rooms were tested: the first was what might be called a typical classroom; the other was a large room used for the viewing of television by large groups. The latter was separated from a contiguous larger space by folding partitions, thus providing great flexibility of space and use. A continuous window was installed on the exterior wall of the typical classroom, and a short length of view window was located on the corridor wall. There was the usual corridor door. Some of the typical classrooms are equipped with television. Teachers do not like the glass in the corridor wall and believe this to be responsible for the intrusion of noise of corridor traffic into the classroom; some teachers claim that the sound of television from neighboring rooms interferes with their work; a few teachers say that the speech of students in the room is not easy to understand. Some students comment that at times it is difficult to make themselves heard by the instructor; quite frequently criticism was directed at noise from the hall. Negative criticism was balanced by many favorable comments about the environment. The administrators believe that the acoustical environment in general is good.



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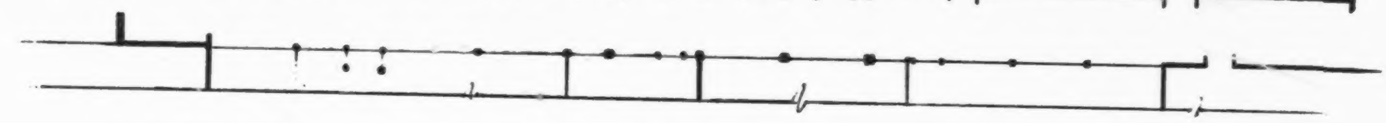


section

NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
E-6 - E-5	21	21	27	33	35	38	29
E-16 - E-4 door open	23	22	22	17	21	20	21
E-16 - E-4 door closed	28	27	28	29	32	31	29

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
E-5	.01–	53	8060	.71	.66
E-16	–	–	22255	–	–

CLASS IN SESSION (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
E-5	67	65	63	56	55	60–70	65
E-16	–	–	–	–	–	58–65	62

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

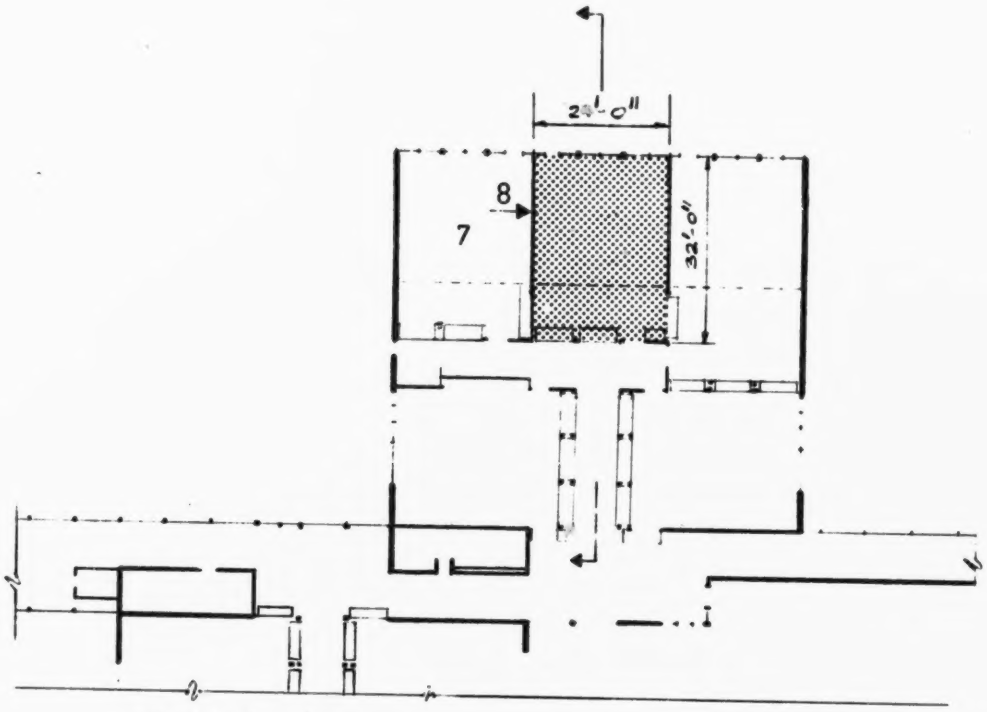
	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
E-5	65	59	57	52	49	59–65	62

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	25	65	10	0	0

SCHOOL
2
EC

This is a high school where the academic classrooms are generally grouped into clusters of about five classrooms each. These classroom clusters are connected by enclosed corridors. Partitions are made up of modular storage cabinet units, which are connected together; above these cabinets continuous glass runs from door height to ceiling. Teachers comment that sounds from neighboring rooms and from the internal corridor of the room cluster are transmitted through the storage cabinet partitions and through the ventilation ducts, but this distraction is regarded as tolerable. Students generally react to the environment of this school in the same way as the teachers.



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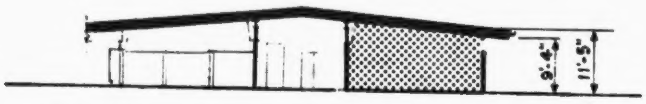

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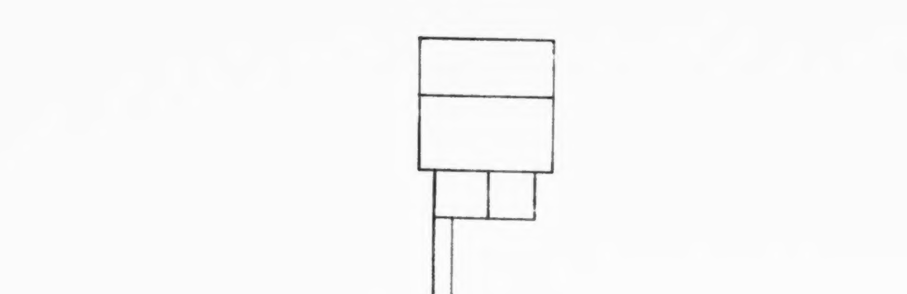


key plan

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
7-8	–5	9	22	25	33	36	20

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
8	.05	35	7607	1.10	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
8	58	53	48	45	41	58-69	63

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
8	52	43	39	36	31	57-62	59

TEACHER OPINION POLL (%)

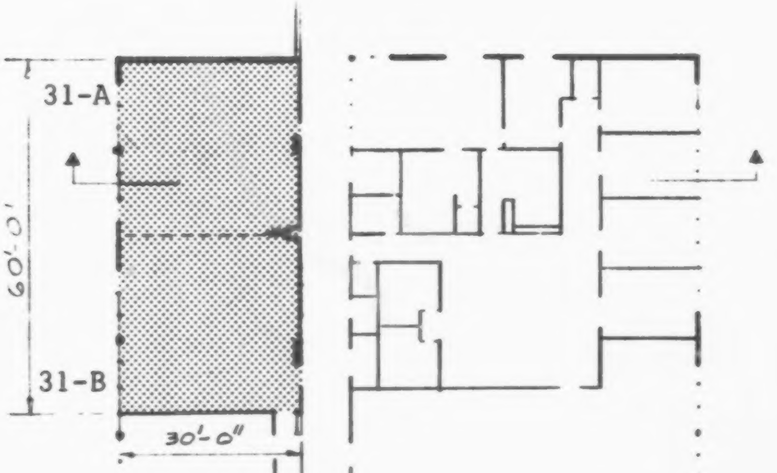
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	25	62	7	0	6

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Background Noise	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
8	57	50	39	33	26	18

SCHOOL
3
EC

This is an elementary school where a team-teaching program is followed. One of the outcomes of this program is pairs of rooms which are separated by folding partitions; when partitions are closed, two classes may be taught, each class being approximately thirty students in size. When this partition is opened, two classes may be joined under the guidance of a single teacher. There are two building wings in this school, one of which is provided with the above divisible rooms, the other wing divided into more conventional classrooms. One of the administrators on Form 3 says that he would have liked to have more such divisible rooms in the more conventionally planned wing. These divisible rooms represent the portions of the plant where the acoustical design deviates from the



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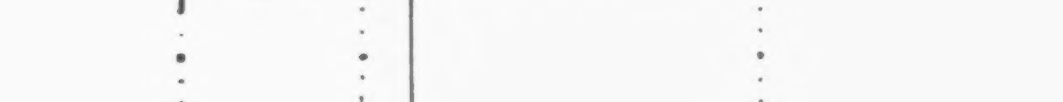


section

conventional, and apparently these divisible rooms are not only acceptable, but liked by teachers and students. The teachers comment that record players can be heard through partition dividers, and occasionally voices are said to be a minor distraction. There are no strong complaints. Students complain faintly about the distractions of others talking. On the teacher opinion poll, 17% rated the environment *not acceptable* because of lack of sound interception between classrooms through the movable partitions.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
31-B - 31-A	7	14	22	24	26	32	21

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
31-A	.01–	48	8100	1.05	.66

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
31-A	59	64	60	52	50	60-74	67

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

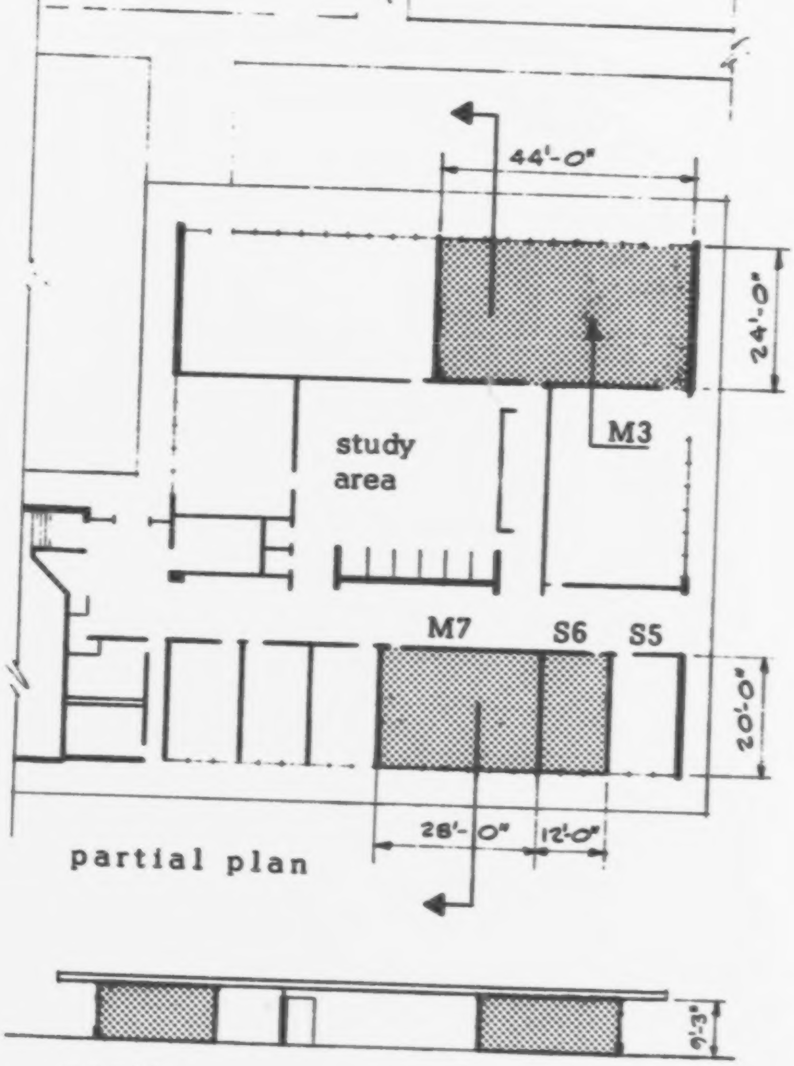
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
31-A	55	54	51	47	46	58-64	62

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	25	58	0	0	17

SCHOOL 4 EC

This school is of particular interest because of a well-administered educational program involving a full team-teaching approach, and also because the architectural plan has been carefully worked out to house the program. The teacher opinion poll indicates the school rated 84% *good* or *excellent*. Of the 10% *not acceptable*, only two teachers expressed criticism of acoustical environment; the others criticized the inefficiency of the ventilating system, a lack of privacy, and some said that views through windows were distracting; another commented that the lack of a home room did not encourage responsibility in the care of the school. In the replies listed on Form 1 many teachers further complained of inadequate ventilation, and the noise of mechanical equipment; some teachers valued windows for views while others simply objected to windows.



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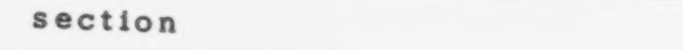

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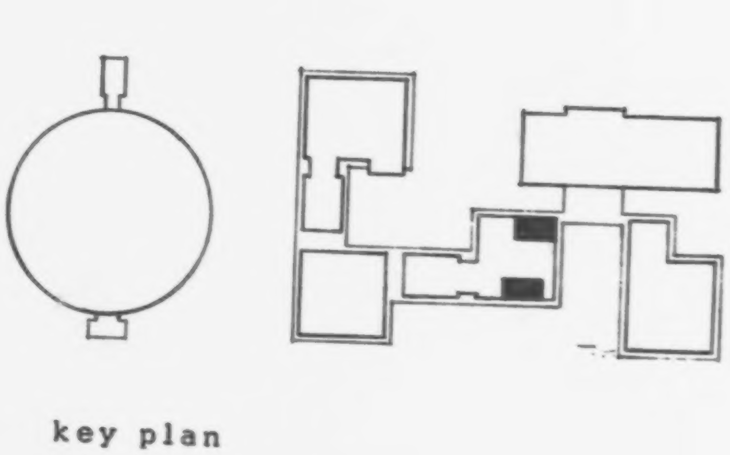


key plan

Some criticism was voiced because of sounds intruding from adjoining rooms. The design of the school provides a variety of room sizes; but the sound interception between major rooms is about the same as in more conventional schools. Smaller seminar type rooms had much less interception. Generally speaking, questionnaires did not reveal any acoustical abnormalities, nor was any special criticism directed toward the acoustical environment.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
S6-M7	19	21	33	38	42	44	33
S5-S6 door open	18	18	21	21	20	19	20
Study area-M3 door closed	21	23	25	25	17	14	21
S5-S6 door closed	17	18	22	26	23	28	23
Corridor-S6	12	17	24	27	25	35	24
Study area-M3 door open	9	11	5	3	-1	-2	4

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
S6	.01–	49	2200	.62	.44
M7	.01–	49	5140	.88	.58
M3	.01–	49	9700	1.07	.70

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
S6	64	63	55	51	50	62-74	69
M7	64	60	56	52	51	61-75	66
M3	60	60	58	56	51	60-78	67

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
S6	57	55	49	49	48	60-67	63
M7	56	54	49	49	49	58-65	60
M3	55	53	50	49	49	57-61	59

TEACHER OPINION POLL (%)

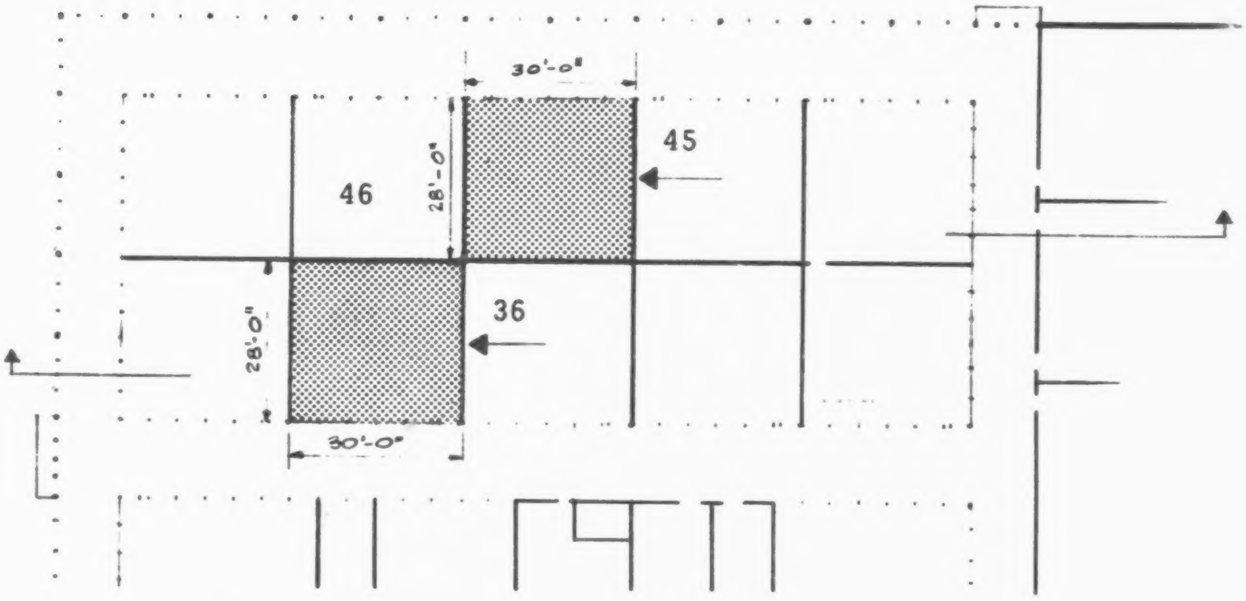
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	45	39	0	6	10

SCHOOL

5

EC

This is a junior high school which is characterized by a compact, loft-type plan. This building does not exhibit any of the characteristics of the open plan, and the methods used for acoustical separation between classrooms are in accordance with customary practice and standards. Teachers' comment is almost uniformly favorable; the greatest distraction to one teacher was the sound of students whispering. There were the usual criticisms, which were quite mild, about the sound of the ventilation system. Students are favorable in their opinion of the school.



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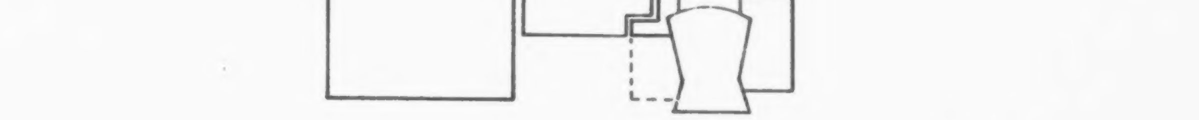

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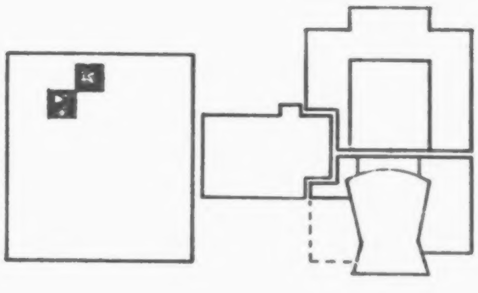


key plan

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
46-45	19	28	33	35	38	38	32
46-36	16	32	41	50	57	60	43

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
36	.01–	35	7560	—	—
46	.01–	33	7560	—	—
45	.01–	41	7560	1.04	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
36	58	55	51	49	40	62-68	64
46	57	52	50	42	39	58-68	63
45	58	54	49	39	35	62-68	64

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
36	55	43	41	35	30	60-62	61
45	53	43	39	33	28	59-61	60

TEACHER OPINION POLL (%)

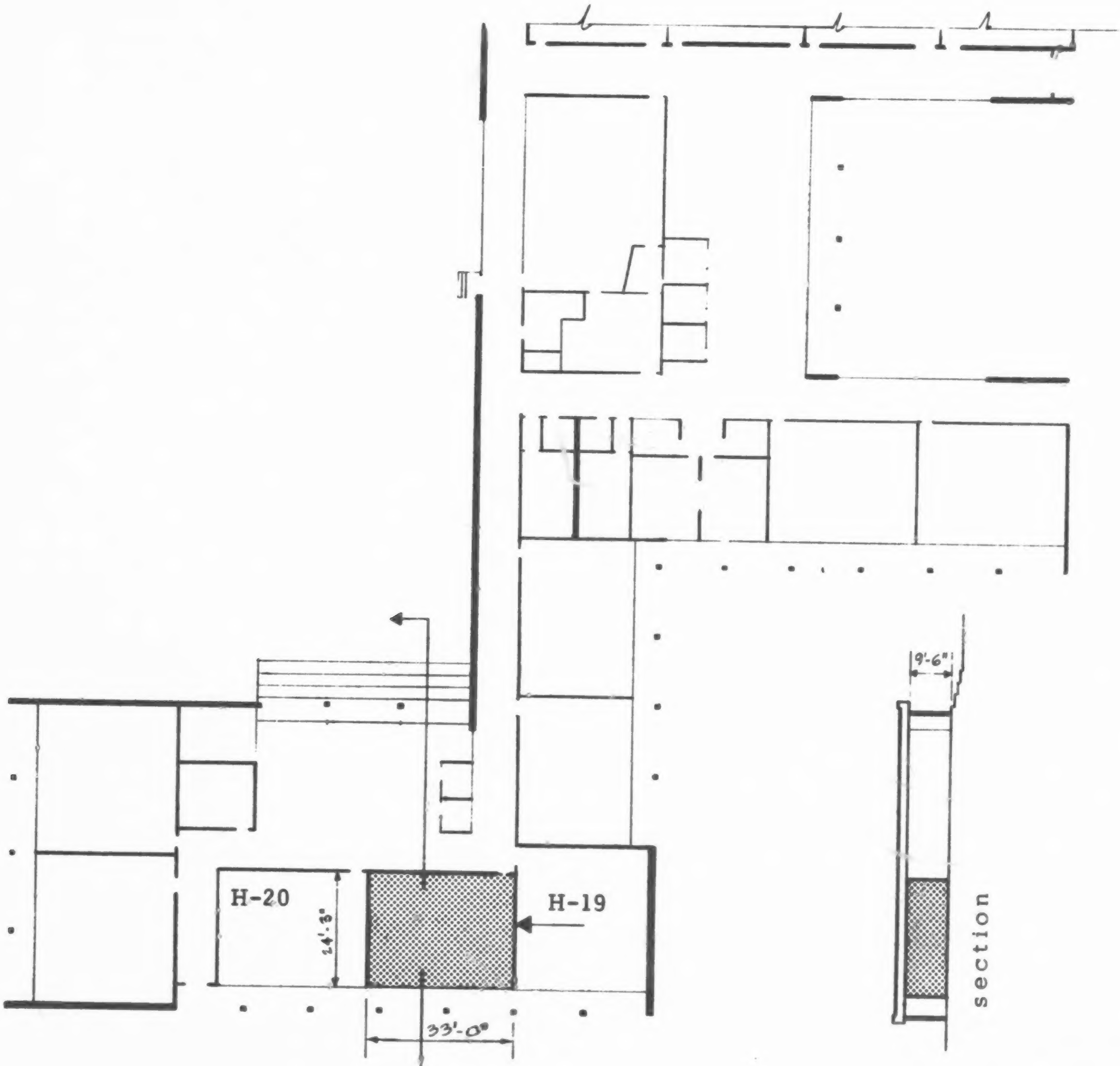
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	70	27	3	0	0

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Air Unit	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
Rm. 36	57	50	42	40	34	28
Rm. 45	60	50	40	34	27	18

SCHOOL
6
EC

This is a junior-senior high school facility arranged interestingly in a dispersed plan. The tested room is not an open-type classroom but has the customary acoustical separation from its neighboring rooms. The tested room is typical of the environment of the school. This is a new facility, and experience in its use is limited at this time. Comment by teachers indicates some difficulty in understanding speech in the classrooms; the investigators believe this is the reaction of teachers to an environment which has too much reverberation. No student complained of any difficulty in hearing teachers or of making himself understood by others.



partial plan

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
H-20 - H-19	14	23	34	35	45	47	33

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
H-19	.01–	49	7500	1.17	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
H-19	63	63	56	50	46	55-75	69
H-20	62	56	56	51	50	66-75	69

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
H-19	62	57	55	48	44	49-55	52
H-20	42	36	32	25	24	52-57	54

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	33	50	17	0	0

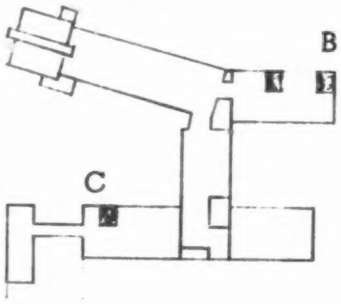
SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

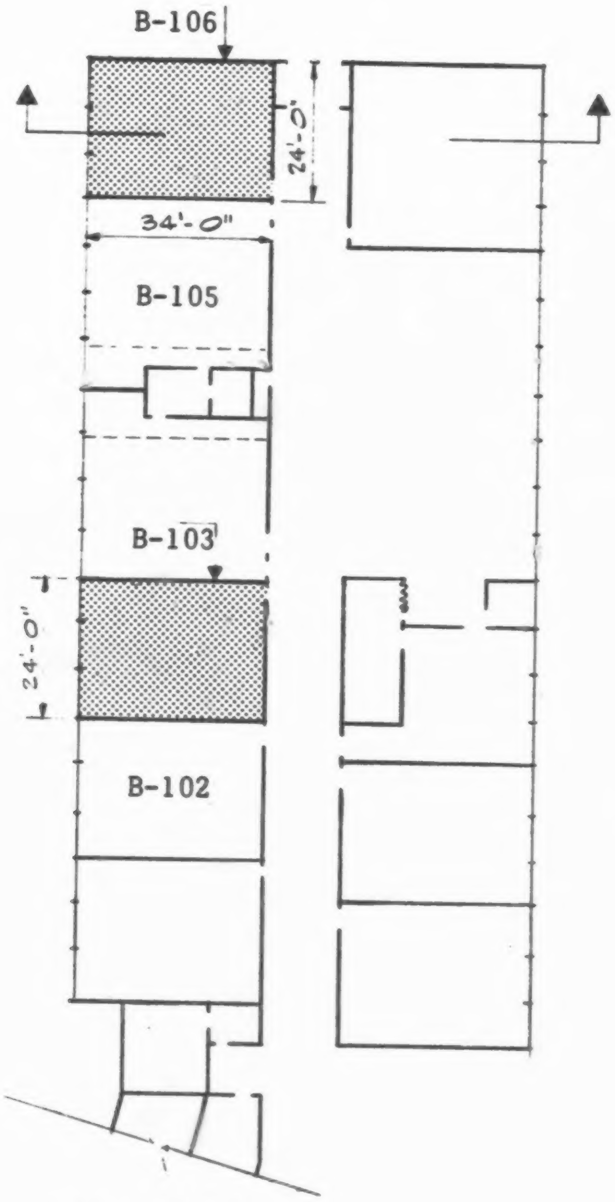
Air Unit	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
H-19	55	52	42	41	29	25
H-20	55	54	42	41	29	18

SCHOOL
7
EC

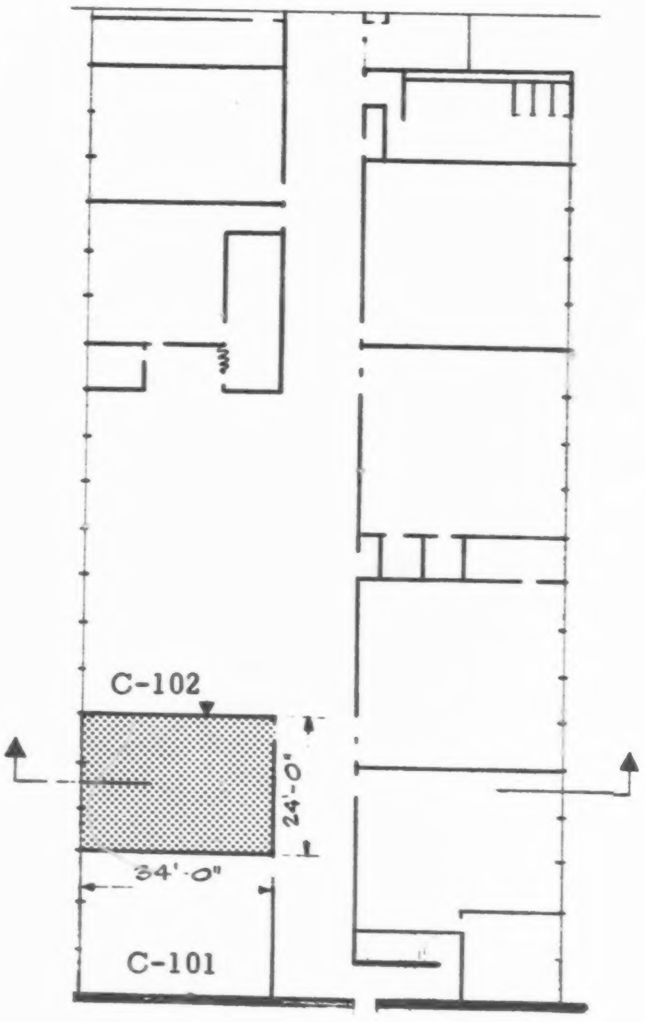
This school facility comprises both a junior high school and a senior high school in a series of connected building wings. In the senior high school, carpeting is installed as a floor covering in certain classroom areas, while asphalt tile is used in the junior high school classrooms. This affords an opportunity to compare the teacher opinions on two kinds of classroom environment; note the difference in the teacher opinion polls. This is a two-story building in some parts and one-story in others with a double-loaded corridor plan; there is nothing about the design of either carpeted or uncarpeted areas which may be considered acoustically bizarre. It is interesting to note that teachers express a clear-cut preference for the environment that includes a carpeted floor. Teachers, students, and administrators speak with general approval of the acoustical environment. This school is not the open plan type; the unique contribution of this school to this research project is the opportunity to measure, by direct comparison, the effects of carpeting and asphalt tile on both acoustical and general environments.

key plan

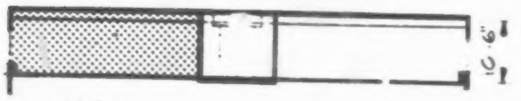




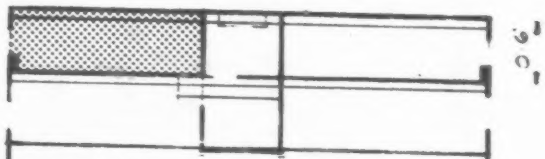
partial plan



partial plan



section



section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
B-105 - B-106 uncarpeted	13	27	36	43	43	47	35
C-101 - C-102 carpeted	10	20	32	39	37	40	30
B-102 - B-103	12	22	33	38	38	41	31

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
B-106	.01–	35	8570	.89	.67
C-102	.01–	38	8570	.58	.67
C-101	.01–	41	8570	–	–
B-103	.01–	40	8570	–	–

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
B-106	67	61	57	48	42	70-75	72
C-102	52	49	47	43	36	58-65	63
C-101	53	47	47	44	40	60-65	63
B-103	58	54	51	46	39	60-67	64

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
B-106	52	44	39	35	30	61-61	61
C-102	47	40	38	34	43	59-63	61
C-101	51	44	43	40	39	62-65	62
B-103	55	48	42	40	39	60-64	62

TEACHER OPINION POLL (%)

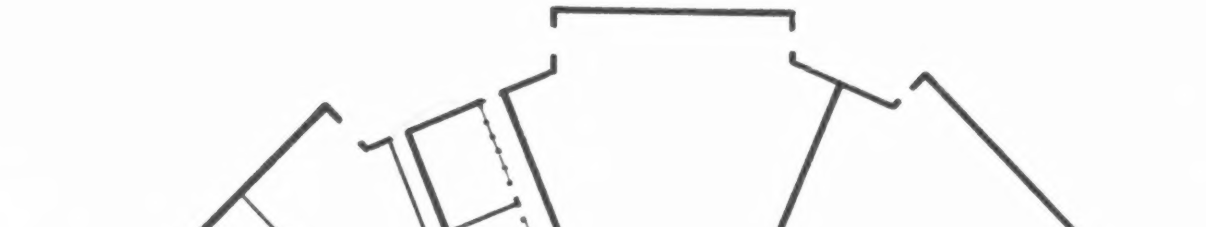
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
(uncarpeted portion)	0	17	51	32	0
(carpeted portion)	25	60	15	0	0

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

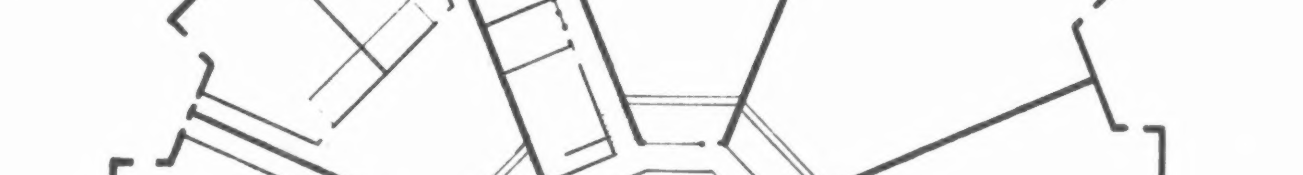
Air Units	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
B-106	51	50	46	39	32	25
C-102	50	43	36	36	30	20
B-103	52	53	49	38	33	25

SCHOOL
8
EC

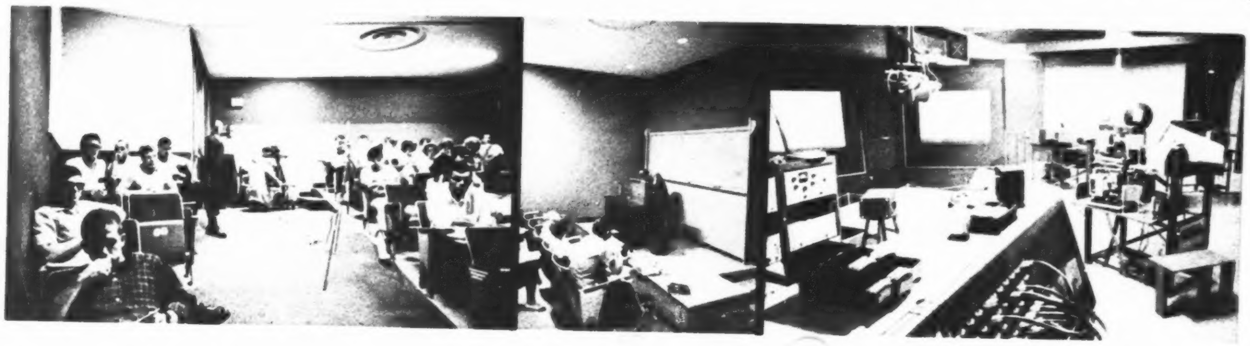
This building is located on a university campus and is divided into a number of lecture rooms. The building is circular and is covered by a flat roof. The floors are inclined. At the center of the building is an area which is used as a projection room for all classrooms for television programs; there may be different programs being projected simultaneously, one into each classroom. The image is projected on a glass screen and is seen from the lecture room; sound is from speakers in each room. This is an ingenious arrangement and seems to work well; if not carefully designed and detailed, the glass walls on which the image is projected would be likely to leak sound. The administrator reports that group discussions in rooms present a minor difficulty. Teachers indicate that they are aware of sound from neighboring rooms, but no complaints are offered. Many complaints are directed toward the fixed seats, which are equipped with a folding writing tablet which is noisy in operation. There are some complaints about seat spacing producing crowded and cramped conditions.



plan



section



The investigators believe that the rooms were designed for best hearing conditions for lecture and television; some difficulty is experienced when students enter into discussions—this difficulty may be related, in part, to the seating arrangement. In other words, a good seat for lectures does not provide the best situation for discussion.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
194-192	28	27	37	45	46	51	39
Proj. 140	30	34	39	41	40	41	37

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
192	.01–	47	7597	.72	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
192	66	70	64	55	54	60-80	73

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
192	55	50	48	47	47	55-60	53

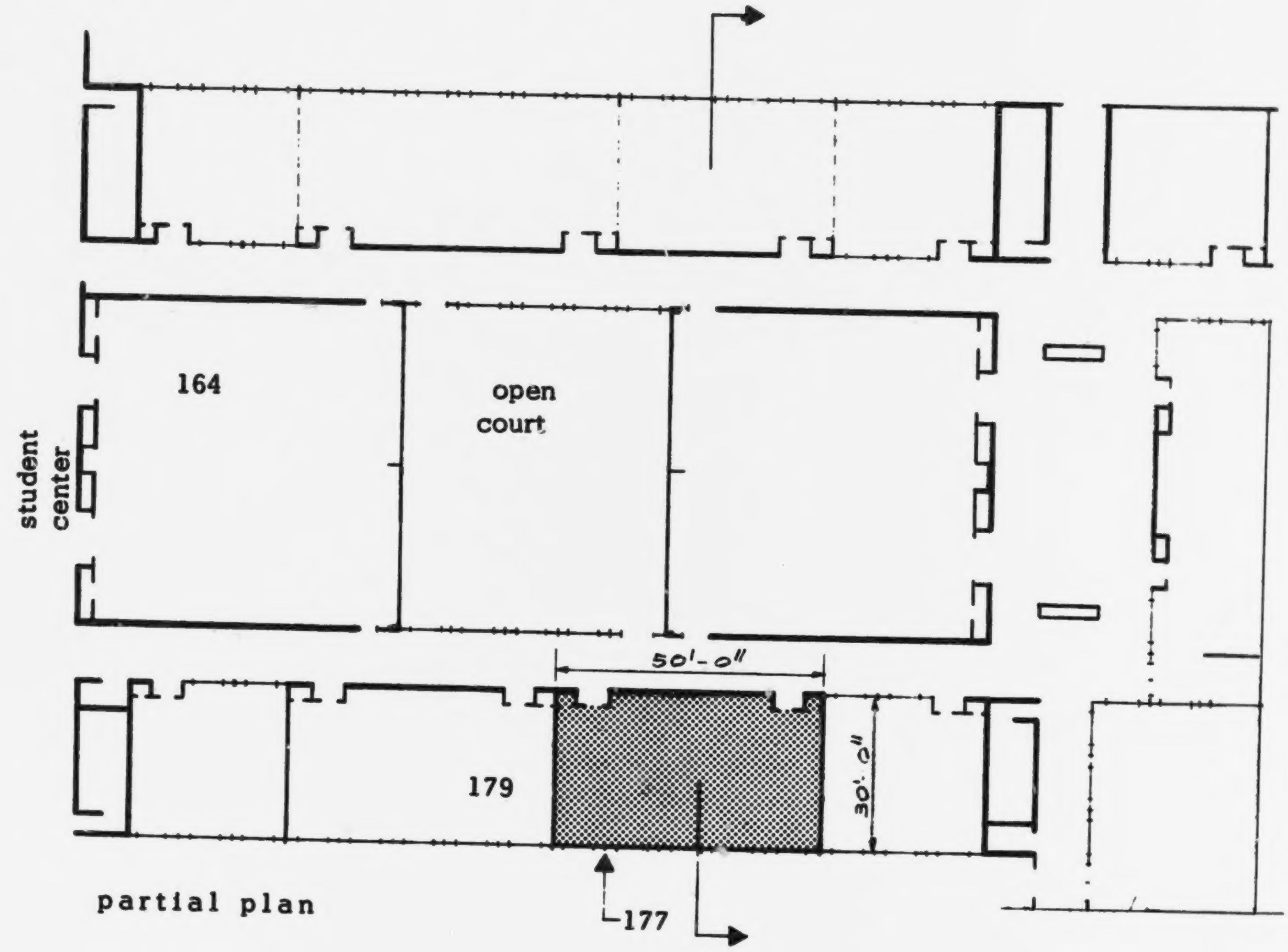
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	63	28	0	9	0

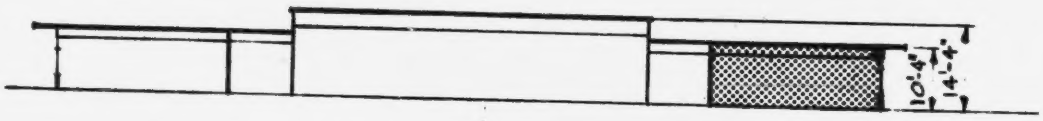
SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Air Units	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
192	52	52	41	32	24	21

SCHOOL
1
MW


164
open court
student center
50'-0"
30'-0"
179
177

partial plan

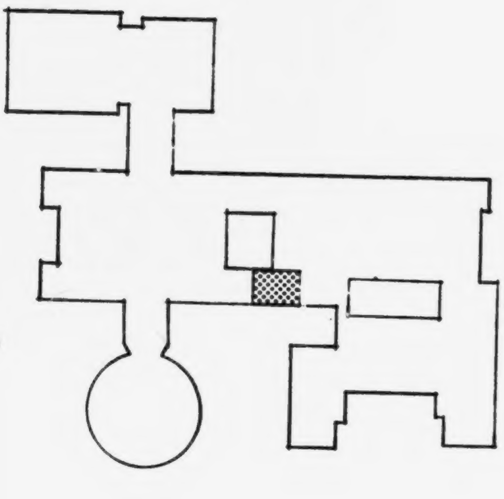


section

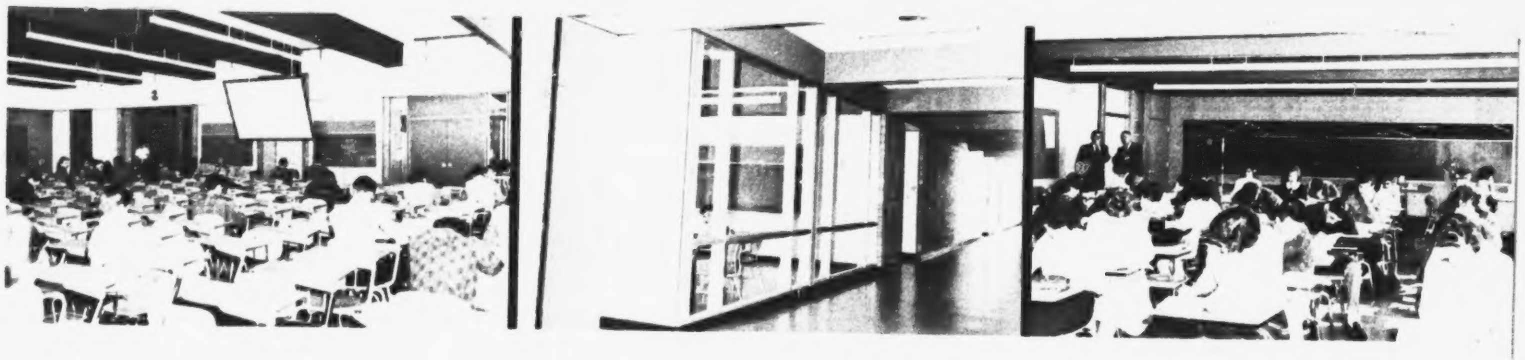
Legend:

Fixed glass partition —+++—+++—+++—

Sliding glass partition - - - - - - -



key plan



NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
179–177	19	23	28	36	43	46	33
Student Center–164	22	23	27	32	30	29	27

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
177	.01–	41	15500	1.68	.77

CLASS IN SESSION (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
177	49	48	46	43	39	61–66	64

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
177	47	47	41	39	43	60–64	61

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	37	31	19	13	0

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Heating Unit Blower	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps
164	49	49	47	39	32	25
177	51	47	48	40	34	24
179	52	51	51	42	35	28

SCHOOL
1
MW

This is a new high school, so new that construction was being completed while these acoustical tests were under way; construction was complete, however, in the areas tested. This school is not an example of open plan design, and the acoustical separation between classrooms is customary. Teachers, students, and administrators speak with approval about the acoustical environment. The performance of operable partitions is apparently quite good. Following are excerpts from the report of the investigator:

"The unusual round auditorium design which also incorporates band and choral rooms had been checked for acoustical performance but this check did not cover the rest of the building. The auditorium and music facilities were not yet completed, and we could only visit them under 95% complete conditions. The gymnasium was almost complete and ready for use, but no classes had been held in it yet.

"Instrumental music was being rehearsed in the studio for closed circuit television, and choral music in another television facility which will be used for storage. The instrumental teacher was asked to fill out a questionnaire based on her present facility, and to attempt to complete one for the band room which she has not yet used. The choral music teacher was asked to fill out a questionnaire for her present room. These facilities, then, are temporary for six to eight weeks or thereabouts. For completeness, the new facilities should be investigated.

"The superintendent acknowledges the temporary problem of the full band rehearsal interfering with adjacent homemaking class. Although this problem is temporary, it is a problem because the architect has permitted an unnecessary acoustical leak at the union of ceiling and double thickness four-inch brick wall, total eight inches (not concrete block).

"This same acoustical leak occurs in every room in the school. It is unacceptable in the guidance area where privacy is important. The condition is not unsatisfactory at other classrooms since sufficient isolation results (other walls are eight-inch painted concrete block), but several teachers stated they could hear adjacent class activities though they did not interfere.

"The same leak from band room into mechanical drawing causes a little interference there, but the teacher says it is not too bad. Furthermore, he lets the students operate a radio or record player to mask the band music. This is temporary in this school, but it shows what can happen in other schools, or in this school with different scheduling.

"The above acoustical leak requires scheduling of homemaking classes. Part band or instrumental group rehearsal is held simultaneously with homemaking classes, but note (from questionnaires) 100% interference reaction by teacher and students. Bass drum, tubas, baritones, trombones, etc. "come through," but flutes, clarinets, etc. not so much. Full band one period later would prohibit homemaking or other classes in the next room, hence none are scheduled.

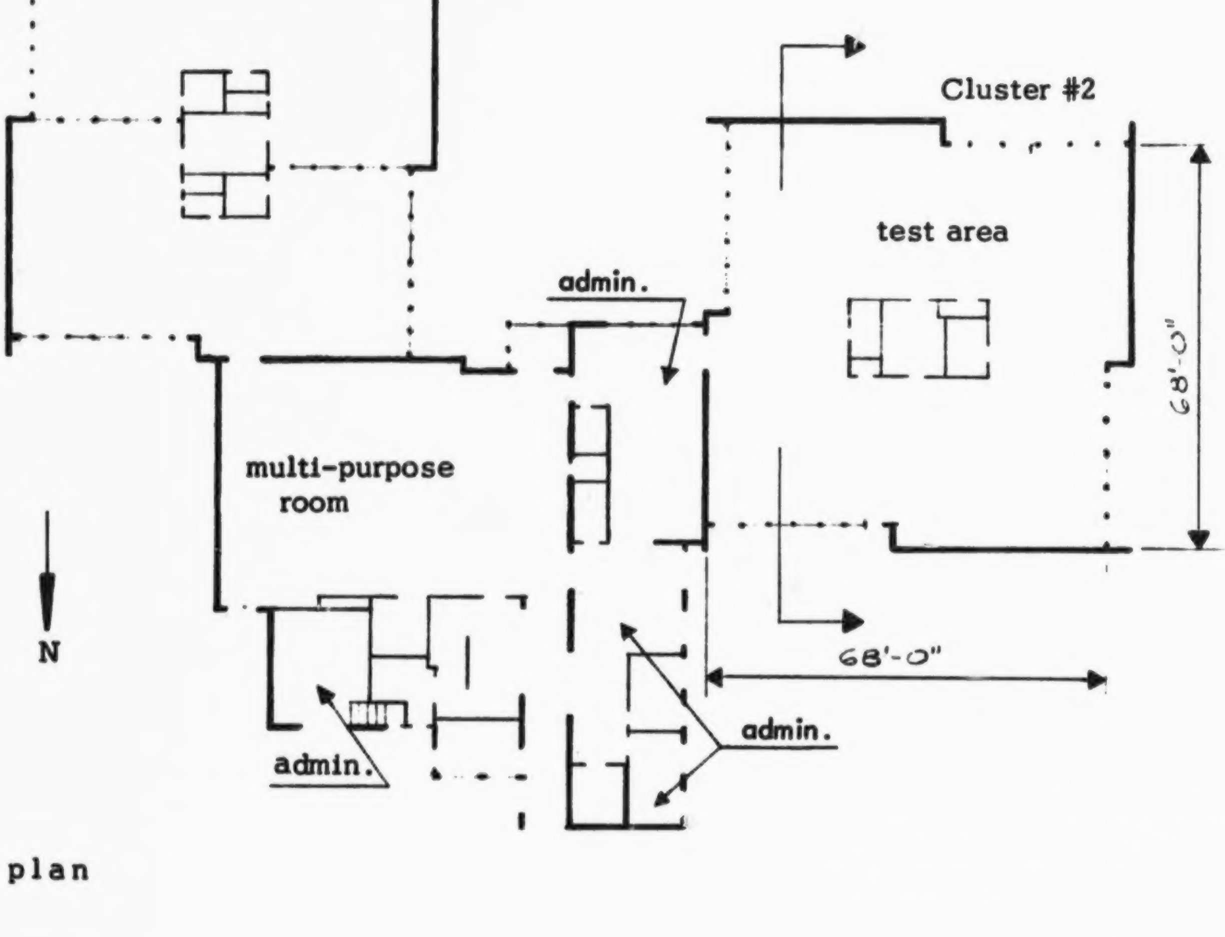
"The glass sliding partitions in the commercial department not only pose no problem but are very good for supervising adjacent classes without a teacher in each room. However, one relatively long typing room and a corresponding long math room have a condition due to the unusual acoustic ceiling in that both teachers report difficulty in hearing students in the back row. Some rooms of this type also have sound reinforcement systems, and it is presumed that these were installed because of difficulty of teachers to communicate, although their questionnaires do not so indicate.

"This school has a large classroom of 300 seats and another just a little smaller. These are used for lectures in English, civics, and similar subjects, to the room almost full. Two openings with pair (double) doors in front ordinarily would be responsible for acoustical leaks from the student center area (lockers, coat racks, lounges, etc.) but time schedules are arranged so that this does not occur.

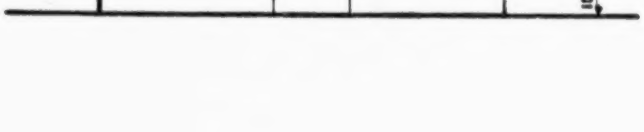
"This room also is used for up to four "seminars" for discussion by groups of 20-30 in each of the far corners at the same time, with apparently acceptable results. The room is relatively low with a good acoustical ceiling on the entire area.

"Ventilation noise was mentioned by several teachers."

SCHOOL
2
MW


Cluster #1
Cluster #2
test area
admin.
multi-purpose room
68'-0"
N
68'-0"
admin.
admin.

plan



section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
SE corner of cluster 2 to NE corner of cluster 2	10	9	7	6	6	8	8
Multi-purpose room to NW corner cluster 1	34	34	33	36	35	35	35

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
South half cluster 2	.01–	58	11160	.73	.73

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
South half cluster 2	64	55	64	65	57	77-83	80

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
South half cluster 2	63	62	60	58	57	76-80	77

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	0	100	0	0	0

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Ventilator noise	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
Cluster-1	44	40	37	36	29	20
Multi-purpose	56	53	50	44	40	31

SCHOOL
2
MW

In this elementary school the teachers teach all subjects to their respective classes except music and physical education. The school has a multi-purpose room with administrative offices located on the side of the multi-purpose room, away from the classrooms. All of the teachers and students are enthusiastic about the facilities. The investigator reports:

"Two "clusters" of four teaching areas each and a multi-purpose room are used and were investigated. Cluster #2 has no walls, partitions, or barriers at all between teaching areas. Cluster #1 is divided into two areas of two class spaces each by a striated plywood and glass full partition with doors. The multi-purpose room is used for assembly, gym, vocal music, instrumental music, quiet study, some active classes, and as a lunchroom. Superintendent, principal, and all teachers agree on their satisfaction with the "cluster" areas but likewise agree on the acoustical environmental problems in the multi-purpose room. The superintendent, in his questionnaire, states that acoustical conditions are compromised to get teaching conditions for their desired techniques.

"The teachers report the adjustment needed when these rooms were used, but that teaching the students a regard for keeping noise down because of adjacent and neighboring classes (especially in the multi-purpose room for gym and games) is good discipline.

"We heard the instrumental music from the multi-purpose room in the adjacent classroom, Cluster 1, through the double connecting doors. Several teachers said they and the students get used to this and it does not bother. This can be heard on the tape recording during the quiet class time.

"Note that one teacher does state it is hard to speak normally in the cluster and be heard. I think this is when students are coming in, and she is trying to get order. She has a fairly strong voice. There is a sound reinforcement system available. The room is relatively low for its area and has a good suspended acoustical ceiling.

"The multi-purpose room is used for vocal and instrumental music and questionnaires from two different teachers report their reactions. Note that they do not agree on the environment for music. Singing in lower grades is carried out in the cluster and the teacher's questionnaire records her reactions about using the space for vocal music.

"The superintendent reports multi-purpose room activities are too loud in the administration area of two small offices and that this is going to be remedied in the near future with an installation of a pair of doors in a suitable location in the corridor.

"The superintendent also indicates that the two unit heaters installed as units completely within the room and suspended from and near the ceiling are noisy. These might be heard in the tape recording of noise bursts.

"Principal states that in all probability the partition in the one cluster will be removed soon.

"An addition to the building is under erection at this time but this will not relieve the multi-purpose room problem.

"Note on one student's questionnaire that he suggests 'walls' as a needed improvement."

SCHOOL
3
MW

This building shows an interesting and unique arrangement of classrooms providing closely related areas. It is a practice teaching high school. The large hexagonal classrooms are divided by an electrically operated movable partition. Study carrels are located in the passageway, outside of the classroom complex. It should be added by the investigators that this is a new school, and more experience is needed to be able to use rooms to maximum effectiveness; the administrator offers this same comment. Since this was one of the first schools tested, no teacher opinion poll was taken. The investigator's report says:

"The delay in completing this work was due first to final adjustment of the electrically operated movable partitions, then to scheduling of classes so that the investigation could be made.

"The classrooms are hexagonal-shaped when not divided with the partitions and there are two sizes of such rooms. Most but not all rooms of both sizes have partitions, either automatic or manual, of the folding type, about three inches thick, with seals between panels and around the perimeter which effect varying degrees of crack sealing.

"This school is still new and many rooms are still not yet occupied. As a result, most rooms divided by movable partitions are not used with the partitions in place.

"Our investigation involved one of each size of classroom, and in the case of the large classroom, a situation was arranged with classes on both sides of an automatic folding partition. This involved rooms A-121 and A-123. Room A-119, adjacent to A-121, also was partially involved.

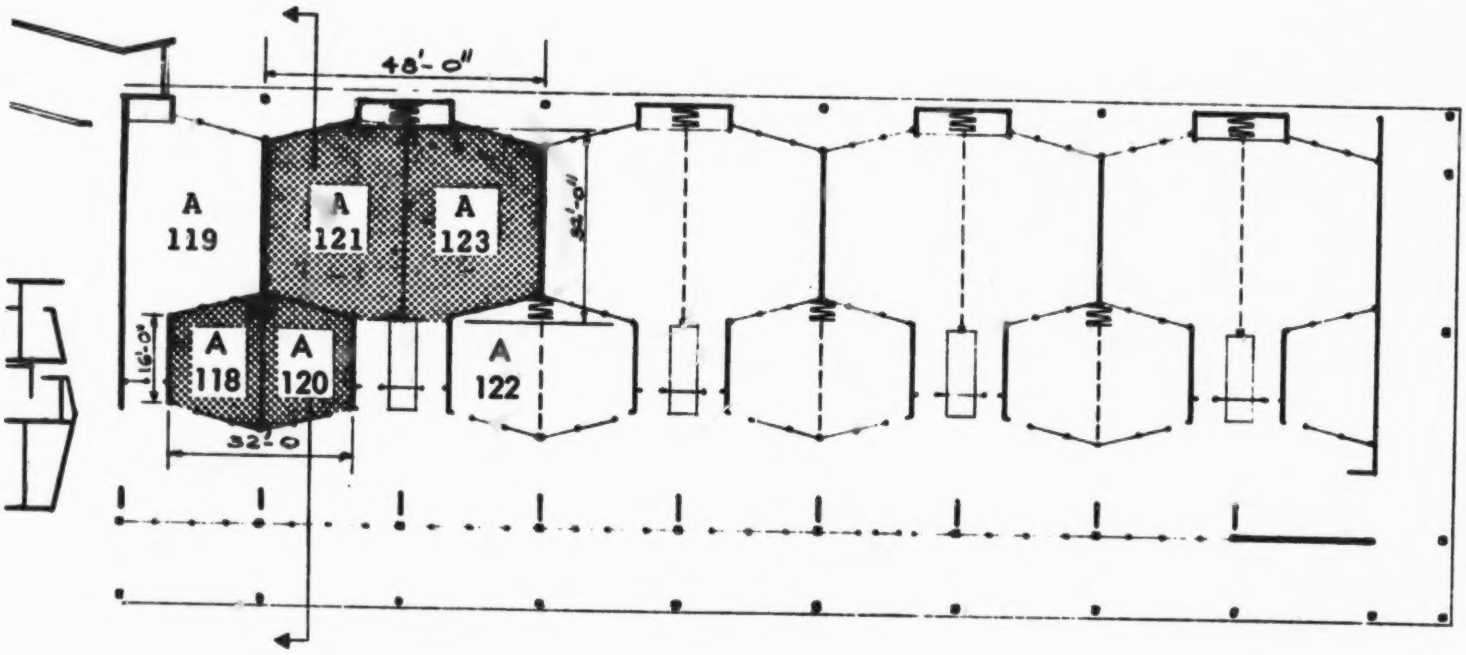
"An accompanying sketch shows room layout and wall design. During our tests a sound leakage path in the wall near the exterior glass panel wall was reported by the Room 119 teacher, although neither she nor three students considered it important enough to mention in the EFL form sheets they filled out. The slight disturbance is experienced during singing or tape-recorded music periods in the Spanish class in Room 121.

"The two teachers in rooms divided by the movable partition mentioned annoying interferences from each other's class, and this is mentioned on their Form 1 sheets.

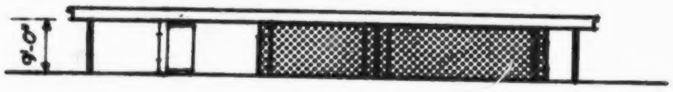
"There is little or no interference originating in Rooms 119, 121, and 123 heard in Rooms 118, 120, and 122, which are small classrooms separated by six-inch plaster walls with no doors or serious leaks. These dividing walls are 16% wired glass near the ceiling.

"There was no instrumental or choral music in progress during our visit. Room D-104 is used for music appreciation and related courses for which tape and disc records are used, but a minimum of singing or instrumental music is done. The room is designed somewhat as a lecture room (sloped floor, partially absorptive acoustical plaster ceiling) and has two pair door entrances and a single door entrance. The comment of noise from the corridor and music activities affecting the adjacent library was given to me. Two teachers filled out Music Forms (Form 4) which should be interpreted as appreciation and not choral or instrumental music.

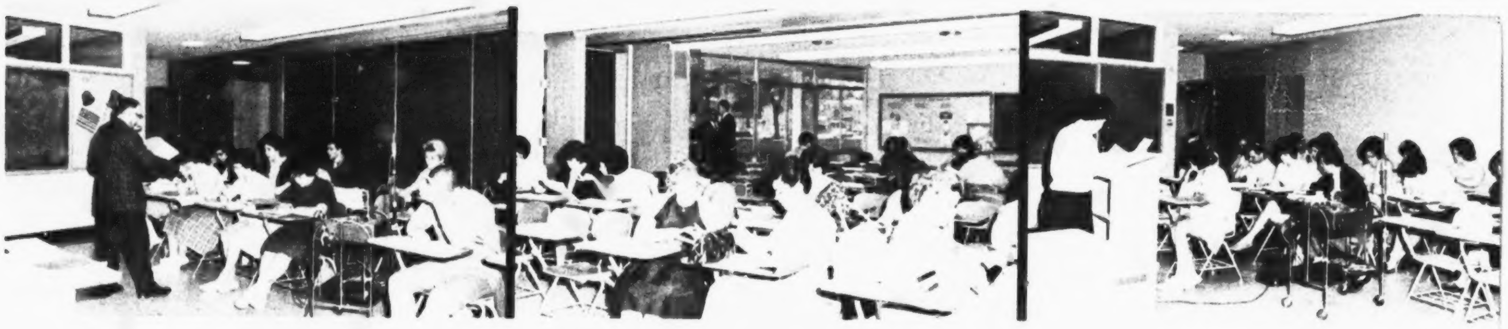
"There is a 700-seat auditorium which is relatively dead for this type of space. It has an acoustical plaster ceiling (partially absorptive), heavy rear wall absorption, and upholstered seats."


48'-0"
A
119
A
121
A
123
33'-0"
16'-0"
A
118
A
120
A
122
32'-0

partial plan



section



NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
A121-A123	10	15	24	28	27	25	22
A121-A120	16	31	38	39	36	43	34
A121-A119	25	26	36	40	36	42	34

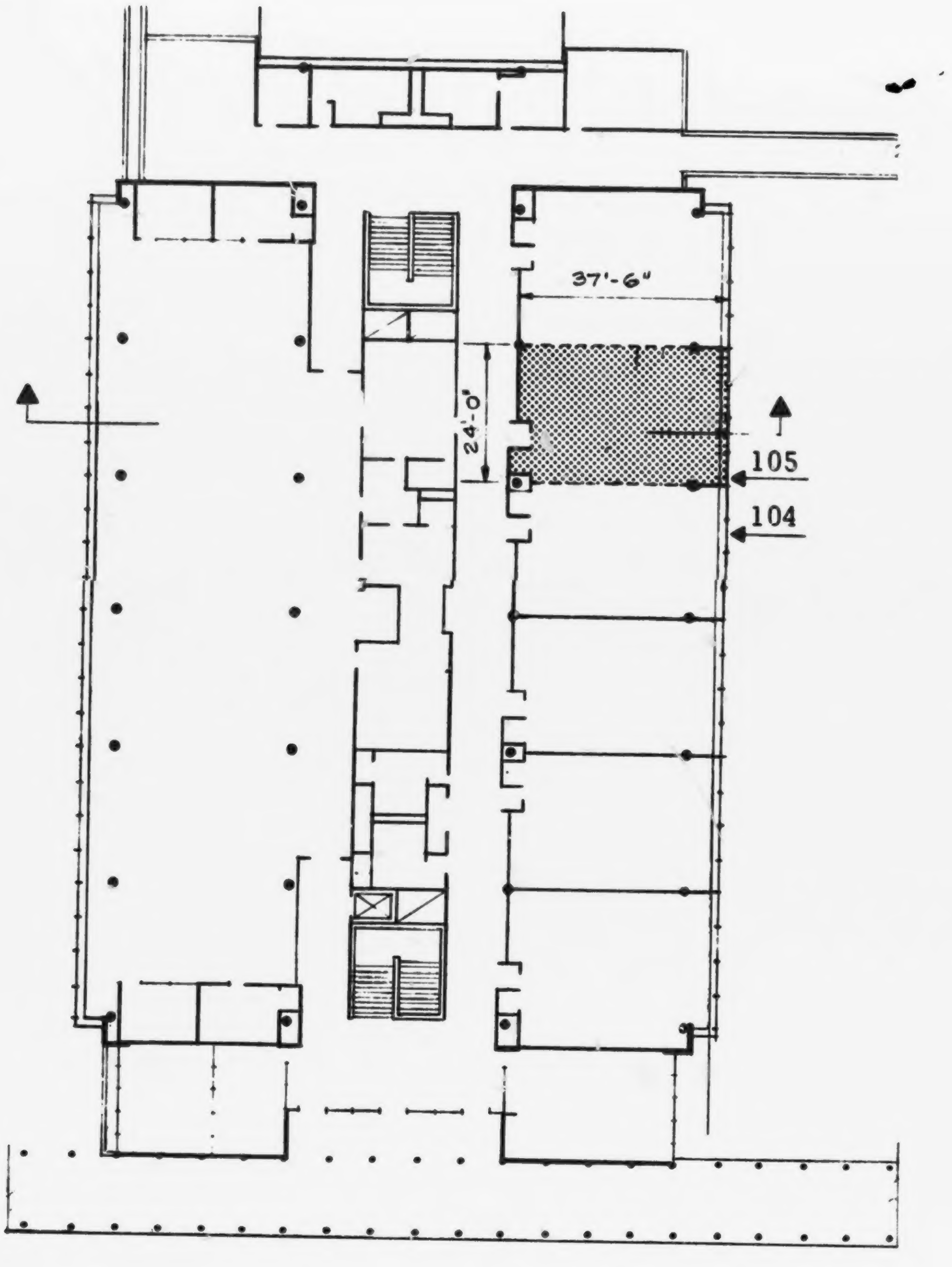
	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
A-123	.02	42	7300	.47	.64
A-119	—	—	7300	.78	—
A-121	.01–	38	7300	—	—

CLASS IN SESSION (Noise Levels in db)

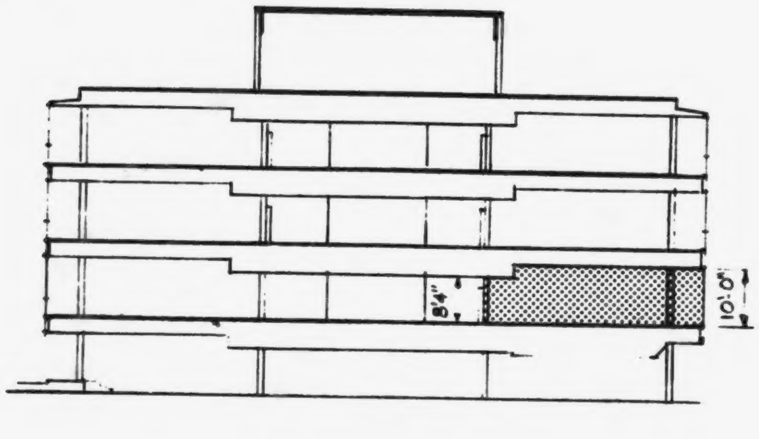
	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
A-123	56	51	49	46	41	58–73	64
A-119	58	53	49	47	51	70–83	78
A-121	54	49	47	43	40	57–65	62

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
A-123	57	44	43	42	42	42–49	45
A-121	49	42	40	38	37	56–61	58


37'-6"
24'-0"
105
104

plan



section

This is a multi-story high school in an urban location; the typical floor has a central core of service elements and instructional rooms flanked by two corridors which give access to classrooms receiving natural light from an outside wall. Classrooms are separated from each other by movable partitions which provide an apparently acceptable acoustical separation. This was the first school that was tested in this research program, and the teacher opinion poll was not taken. There are no complaints that are of significance. One teacher comments, "I think that there should be a little more deadening of the sound of paper rustling and general moving around"; the investigators therefore conclude that the acoustical environment is somewhat live, but that acoustical separation is generally satisfactory.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
104-105	17	19	24	25	28	29	24

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
105	.01−	51	10764	1.13	.71

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
105	56	61	59	54	51	63-78	69

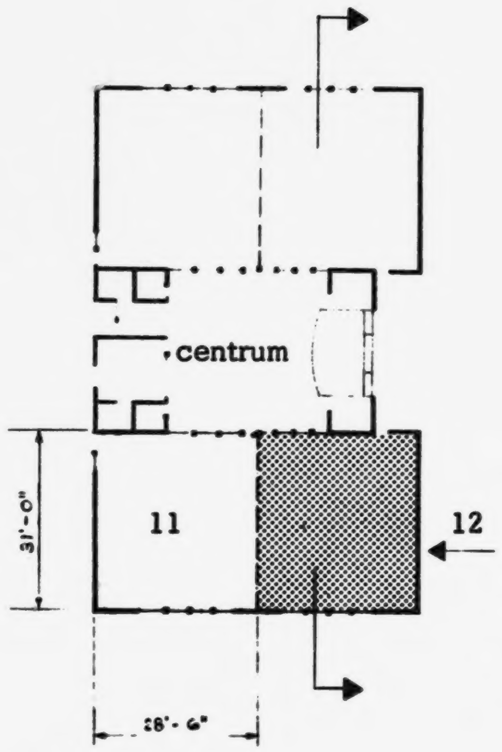
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
105	56	54	52	51	51	65-68	67

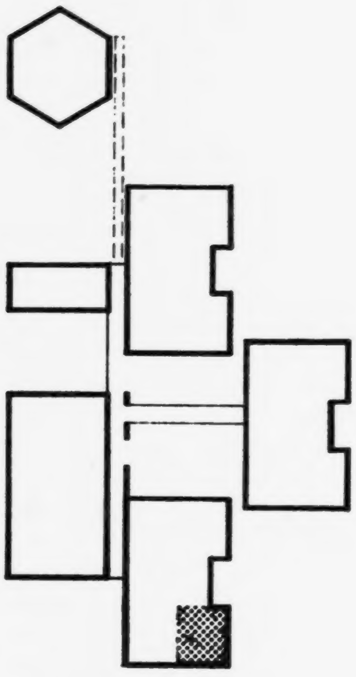
SCHOOL
5
MW

This elementary school is located in the same community as two other tested schools of this report, 8-MW and 9-MW; it is quite similar in design to 9-MW except that the "centrum" classroom area has the same ceiling height as the peripheral classrooms. This school uses a team teaching approach to the educational program. Operable partitions separate peripheral classrooms from each other and from the "centrum." There are chalkboards on the folding partition between classrooms; it has been found that it is not possible for two neighboring classes to write on the chalkboard simultaneously because of noise interference. It is the opinion of one of the investigators that it is doubtful whether or not one class could carry on a noisy learning activity when the neighbor class is engaged in study or testing. The administrator reports: "The building design of this school has challenged the conventional four-wall classroom structure. In most instances, the sliding doors in the centrum remain open so that the Quad in a sense becomes one large classroom with several learning situations proceeding simultaneously. The sound transmitted from one area to another has not disturbed the teachers." Teachers and students appear to like the rooms very much. The last question on Form 2 is, "What improvement of any kind does this room most need?" One student answers, "Less children." There is sound interference from the multi-purpose room which has no doors between room and corridor; sounds carry to classrooms through the corridor.

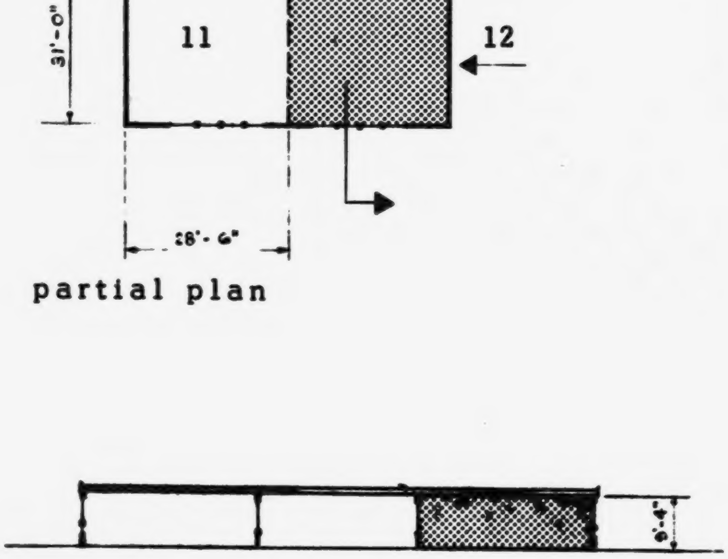
The investigator reports: "The use of the Quad together with the related team teaching is generally satisfactory to principal and teachers. The principal indicates the most important acoustical 'situation' is the noise of gym activities in the multi-purpose room heard in one of the quads and especially in Room 9, which is closest and has a door in the critical area. This situation resulted from



partial plan



key plan



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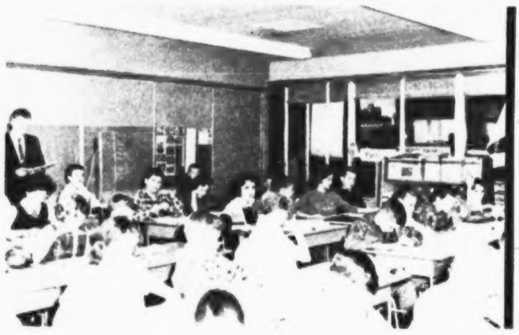


omitting from final construction a wall and door originally planned for the multi-purpose room. The condition will be remedied shortly by installation of a pair of doors in the corridor at a strategic location.

"A second, although not nearly so important, situation is the interference in the four quad rooms when sound movies or recordings are scheduled in the centrum or other loud activities are carried out there. Although teachers would like to leave their doors open to the centrum, they do not because of noise. The partitions isolating the centrum are adequate with doors closed, but not when open. This is because the acoustical ceilings are inadequate. (Note that this condition of inadequate design is quite the opposite for an identical architectural layout in School 9-MW where doors are always open with no resulting interference.)

"Folding partitions separating each two rooms of the quad are inadequate, not because of inherent partition design, but because of inadequate installation conditions at floor and edge cracks. Chalk noises and talking interfere with the adjacent class. Classes therefore are arranged so that the rear rows are nearest these common partitions.

"The superintendent also points out rumble noise of the furnace interferes with hearing in the multi-purpose room when used as an assembly room."

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
11-12 Door closed	19	23	26	27	25	26	25
11-12 Door open	19	23	24	25	23	25	23

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
11	.01–	64	8210	—	—
12	.01	47	8210	.57	.67

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
11	68	67	69	67	66	78-90	82
12	47	49	47	46	43	60-65	63

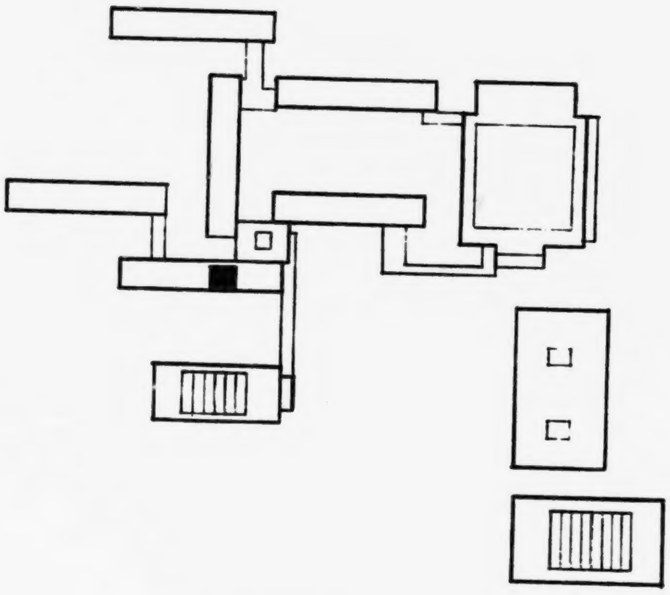
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
11	66	65	64	64	63	80-82	81
12	46	44	45	47	49	60-65	61

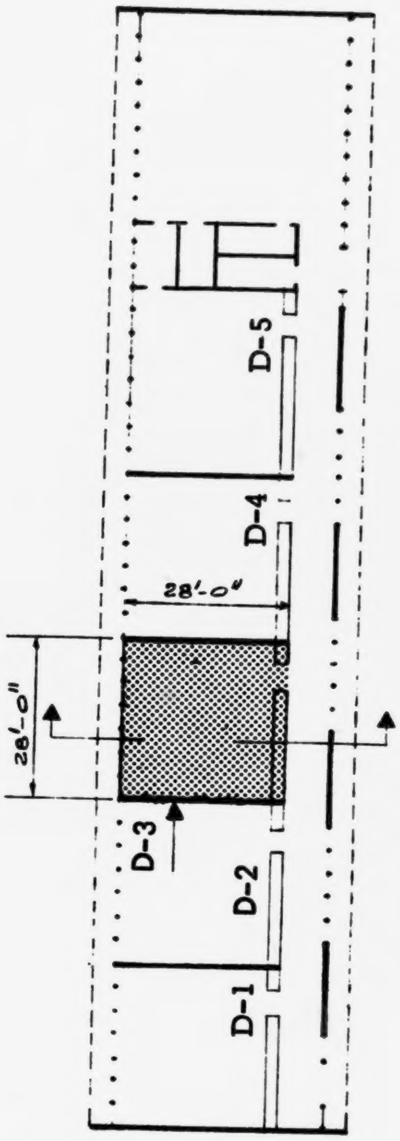
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	8	77	8	7	0

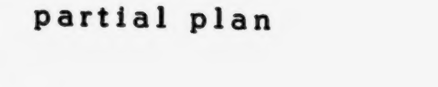
SCHOOL
6
MW



key plan


D-5
D-4
28'-0"
28'-0"
D-3
D-2
D-1

partial plan



section

Although the tested classroom of this high school may appear to be quite conventional from a casual inspection of the plan, it is unusual in that the separation of classroom from corridor is accomplished by a low wall of student lockers, the doors of which are placed on the corridor. The classrooms therefore are not protected from the noise of corridor traffic, nor are they separated from each other acoustically. Teachers comment that they (the teachers) minimize work that requires open discussion by students so they will not distract the work in neighboring rooms. The teachers are somewhat distracted by unwanted sounds from adjacent rooms, particularly sound films and record players. Teachers and students seem to notice the sound of footsteps in corridor. Teachers have accepted the open environment and appear to be tolerant of conflicting sounds; they cooperate to minimize distractions and work under the conditions provided by the architectural design. The pleasant, open atmosphere of the school has impressed the students, and although they are aware of noise distractions they seem to tolerate them. Students, teachers, and administrators comment on the sound of approaching and receding footsteps in the corridors.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
D-2 - D-3	13	12	13	16	20	22	16
D-3 - Corr. outside D-3	4	3	5	5	7	6	5
D-3 - Corr. outside D-2	10	13	15	15	17	19	15
D-3 - D-1	6	21	26	28	30	33	26

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
D-3	.02	50	7450	.60	.65
D-5	—	—	7450	.60	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
D-3	56	55	52	49	49	63-75	67
D-4	56	55	51	50	49	64-66	65

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

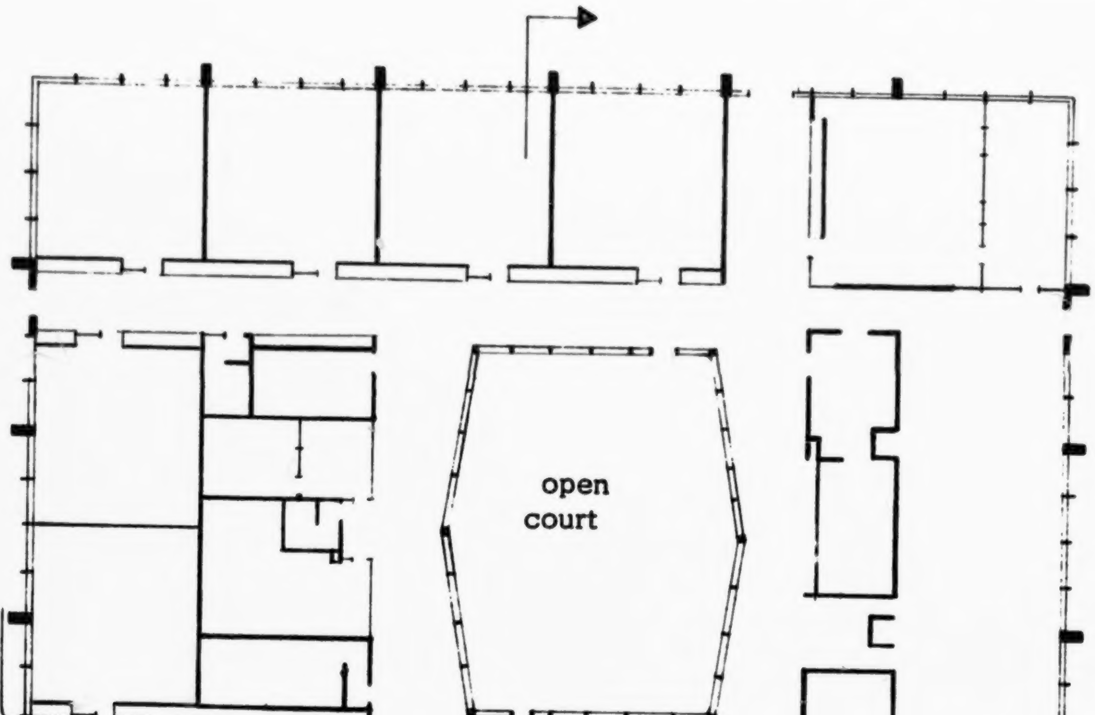
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
D-3	56	55	51	50	49	64-66	65

TEACHER OPINION POLL (%)

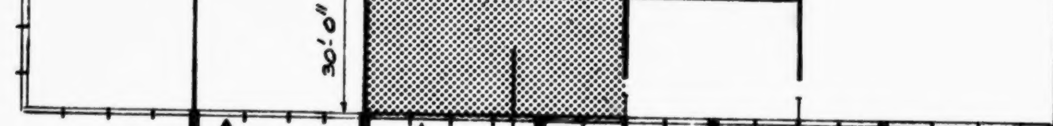
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	0	33	39	17	11

SCHOOL
7
MW

Classrooms in this high school do not represent any departures from accepted practices in design. Ventilation louvers are placed over doors from classroom to corridor. The school is bright, colorful, and airy. The degree of acceptance of this school by teachers is shown by a rating of *excellent* by 67% and *good* by 27% of the teachers in the teacher opinion poll. Some unfavorable comment was raised because of the noise from corridor traffic and lockers and noise from adjoining classrooms; the ventilating louver over the door was sometimes blamed. Unfavorable comment was generally scarce. Students responded quite favorably to this environment.



plan



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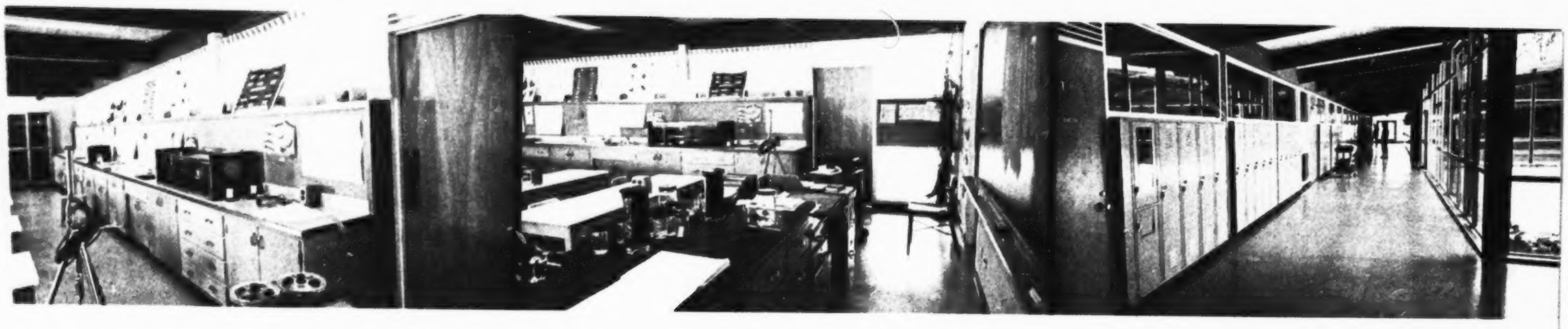


NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
305-304	29	29	30	32	37	35	32
304-Corr. outside 304	19	22	25	25	25	29	24

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
304	.01–	47	12150	.63	.73

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
304	57	67	53	49	46	62-70	65

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
304	55	52	48	47	46	60-65	62

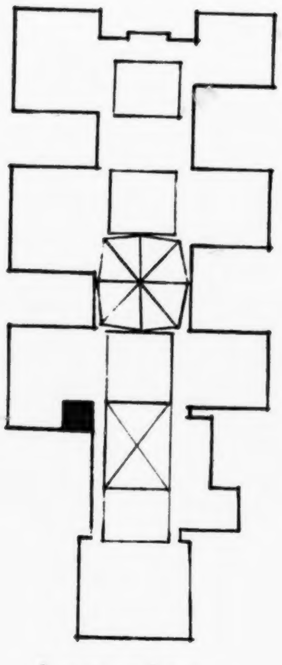
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	67	27	6	0	0

SCHOOL
8
MW

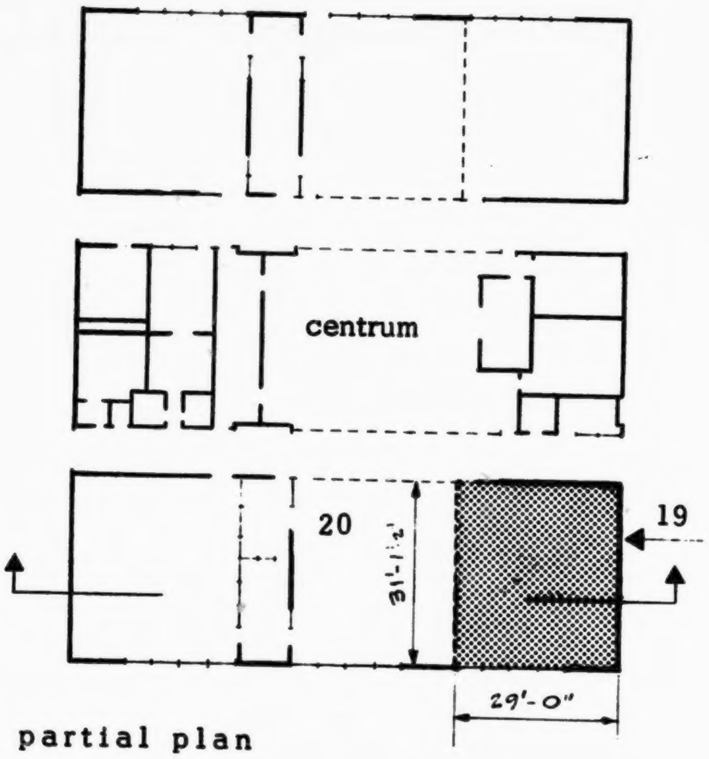
The plan of this recently constructed high school consists of a number of building units, each one of which houses learning areas for the major subject matter areas. The team teaching technique is widely used, and to make it possible to combine or to separate the classroom areas, various kinds of operable partitions are used. There are relatively few fixed partitions in the building unit where the tested classroom was located. The investigators were told that the school started operation before folding partitions were installed by the contractor; after partitions were in place many of the teachers expressed a preference for the classrooms without partitions. The central area is a room shared by all of the peripheral classrooms. The administrator comments about the acoustical environment: "We feel it to be above average..." Teachers generally speak with approval about the environment, but there are many complaints about noise interference from the gymnasium and the lunch room, which do not have doors; they are located in neighboring building wings. Teachers and students like these classroom areas.

The field investigator reports: "The unusual plan of this school includes a 'Quad' of four classrooms with a 'Centrum' class area centrally located with respect to them. Corridors separating classrooms and centrums have folding plastic partitions and glass and aluminum partitions. Folding partitions divide the classrooms.


key plan

"Both superintendent and teachers acknowledge acoustical interference in classrooms due to sound movies, record playing, and other loud sounds from centrum areas. The multi-purpose room when used as a lunchroom causes background noise in at least one classroom. This results because the multi-purpose room has relatively large access openings or doorways which are not supplied with doors. Another acoustic shortcoming is the interference of band music heard in the choral room, in spite of apparently good architectural design with seemingly good buffer rooms between. The leakage paths are complicated and numerous. The choral teacher states the ventilation ducts are responsible. We note that a commercial duct silencer has been installed in one duct, and that there are other paths which also are responsible.

"It is interesting to note that the instrumental instructor stated that the room was supposed to be soundproof but that it was not. He referred to two specific situations. The band room proper, designed as a band room, required more sound-absorbing material. Also, the several practice rooms were not sufficiently isolated from the instrumental room even though short connecting ventilation ducts were sound treated.



partial plan

section

"Rooms generally are not well designed, in part because the ceiling acoustical treatment is insufficient to balance the large glass areas.

"It is the writer's feeling that the corridor acoustical treatment if properly designed would reduce noise in classrooms even more than presently.

"The 'Quad' architectural design of this high school is carried out in some respects in the two elementary schools which we visited in the same city. This design is employed to facilitate team teaching techniques.

"The folding partition in the gym has an eight-foot clear space between its top edge and the ceiling. This partition then provides good visual isolation, but the administrators are considering closing off this space for acoustic isolation. There is no sound-absorbing material in this gym, and teachers report signals from clock and from teachers sometimes are not heard."

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
20-19	24	26	30	30	26	25	27
7-6	31	31	35	41	46	49	39

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
6	.01–	30	—	—	—
19	.07	35	9040	1.05	.68

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
6	53	54	52	48	51	57-67	63
19	48	50	48	47	42	57-66	61

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
6	(47.5	48.5	36	38	26)		
19	35	35	35	35	35	59-59	59

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	0	82	9	9	0

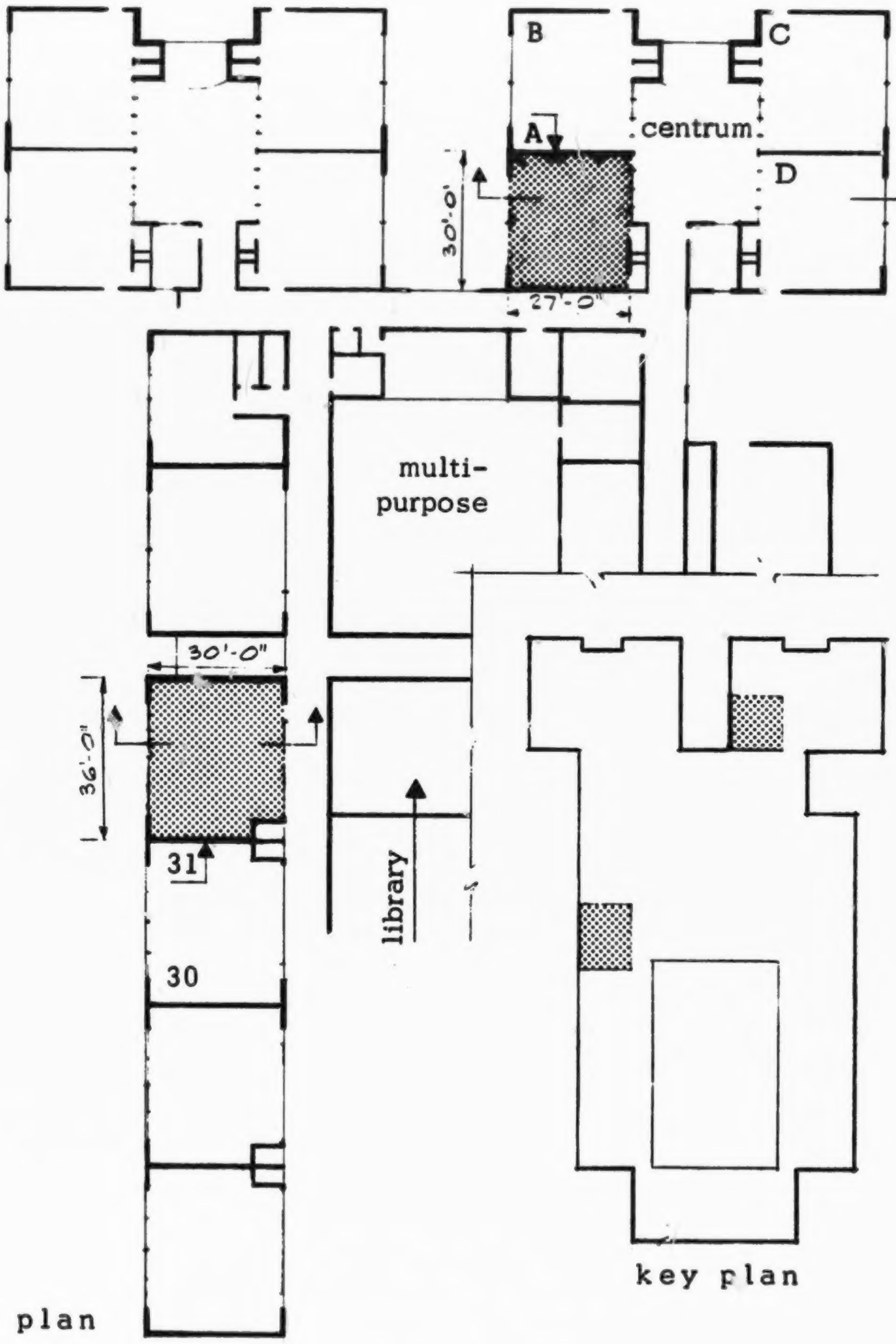
SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Ventilator Noise	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
6	48	41	38	36	29	20

SCHOOL
9
MW

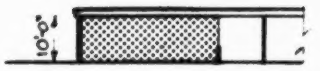
This elementary school consists of an older building arranged around a central court and assembly-gymnasium room. To this has been added two new classroom clusters, each of which is made up of four classrooms with a central workroom or "centrum," used for teaching. This "centrum" has a folded plate roof, and the ceiling height is greater than that of the peripheral classrooms. A team teaching operation is conducted in these clusters. There is an operable partition between classroom and workroom. This cluster is nearly identical to the design shown in School *5-MW* except that the acoustical tile on the ceiling of this school is superior to that in School *5-MW* and the operable partition is slightly different in design. Teachers and students seem quite well satisfied with the acoustical environment in the new classrooms, except for mild criticism about insufficient

continued on page 82



partial plan

key plan



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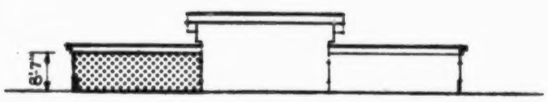


section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
B-A	16	20	23	24	24	23	22
30-31	16	32	35	37	41	41	34
C-A doors open	24	27	31	33	34	36	31
C-centrum door open	12	12	15	16	20	21	16
C-centrum door closed	13	17	24	27	30	28	23

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
Rm A	.01–	61	7530	.55	.65
31	.01–	64	—	—	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
Rm A	67	65	62	59	58	61-64	62
31	71	70	71	67	64	60-67	64

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
Rm A	68	62	61	61	60	61-62	62
31	71	68	65	64	63	62-64	63

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	30	70	0	0	0

SCHOOL
9
MW

continued from page 80

sound interception by the operable partitions.

The investigator's report reads: "The 'Quad' design of classrooms is carried out here as in School *5-MW* and School *8-MW* also visited. The floor plan of the Quad is identical to that of School *5-MW*. Partitions are slightly different, and the acoustical ceilings are a far better type and higher in efficiency in the subject school. As a result, classroom doors which open into the 'Centrum' area generally are left open, and teachers find the acoustical condition very good. We confirmed this by attempting to hear activities from other classes with all doors open, but could not hear anything objectionable.

"The only acoustical situation mentioned by the principal is noise of activity in a fine gymnasium which carries across a corridor to two classrooms where doors are closed at such times. The noise is bothersome only when the gym doors are left open. The gym is a multi-purpose room in that it is also used for assemblies. The two classrooms concerned are part of the older building.

"An important problem occurs with the classroom used for music in the older part of this school. There are four exactly identical classrooms in a row and along a corridor. These rooms have good concrete block walls with doors along the corridor and concrete block walls between rooms. The latter walls are violated by having lavatories between rooms with two doors per lavatory, one opening into each classroom, and ventilation louvers in the doors.

"This situation is satisfactory for classroom work generally, except when loud activities occur in one room and when water is run in the lavatory. But the end room is used for all vocal music which generally is accompanied by piano. The classes for all grades are conducted by a music teacher. The adjacent room is used for storage, since piano music and singing would be too loud in this room for classes.

"The three classrooms of these four that are used have ventilation noise situations. In one the ventilator is very quiet, but the teacher from this room went into the adjacent room and told that teacher that the ventilation (in the second room) was far louder than hers. The second teacher promptly complained as shown on her questionnaire. Note also music teacher's comment on ventilator noise.

"The movable partitions in the Quad were incompletely installed with large cracks that would have led to noise interference had not the acoustical ceiling installation been an exceptional one.

"Multi-purpose room (gym-assembly) has a good installation of efficient metal pan type acoustical tile, and there is no complaint of reverberation. One ventilation outlet of five is excessively noisy and probably interferes with quiet recitation or speech during assembly activity."

SCHOOL
10
MW

This interesting school houses elementary grades. Classrooms do not have doors but have a 6' wide by 11' 6" high entrance corridor about 6' long to each room in the upper grades. Lower grades have a much wider and shorter entrance to classrooms. Principal, teachers, and students express satisfaction and pride in this new building with its modern design. The principal worked with the architect in the design and anticipated some acoustical deficiencies. A stage in each of certain rooms was wanted. It was achieved by designing three steps down into each room and using the piano at the top of the steps for music work. The principal has had to "schedule" classes and work with teachers to "adjust" the learning program to the conditions growing out of the design. He realizes that some acoustical correction is needed and wants to improve conditions as soon as funds permit. All teachers referred to an "adjustment" period in first using their rooms. In all cases these same remarks point out current difficulties.

The objectionable conditions in this school are described in order by the principal and confirmed by teachers.

(1) The music (singing) program in all classes causes greatest interference. The one spinet-type piano in the school is mounted on a steel framework on four rubber-tired wheels, for rolling to each of the classrooms at the top of three steps. Thus it is used on the "stage" for some of the classrooms and in the six-foot-wide entrance corridor for others. The piano music, and to a lesser extent the singing, thus interferes with a number of adjacent classrooms. For this reason art and similar classes not requiring concentration and quiet, are scheduled for adjacent classes.

(2) The activities which open the school day the first period in the morning are the loudest. However, since all classes have those at the same time, they are not considered (by some) to be too objectionable. Several teachers did complain of the situation, which would be difficult when a class has settled down to work while adjacent classes have not yet done so. These loud conditions are from the pledge to the flag, singing, and informal class activities involving loud discussions.

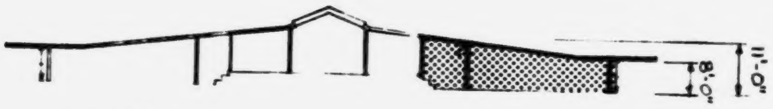
(3) The next important interfering sound is from record playing and sound movies. The principal states that this can be controlled by adjusting to adequate sound volume for the class concerned, but teachers indicate it does interfere.

(4) Other sounds heard between rooms are voices of the men teachers, noise from chalk on the chalkboard on other side of wall, and noise of pencil sharpeners screwed to large area wood panels which are good sound radiators.

Classrooms have only a relatively small area of the ceiling covered with acoustical tile and have a large glass area. More ceiling tile probably would change conditions only slightly.

These are self-contained classrooms and generally each teacher teaches all subjects.

SCHOOL
10
MW



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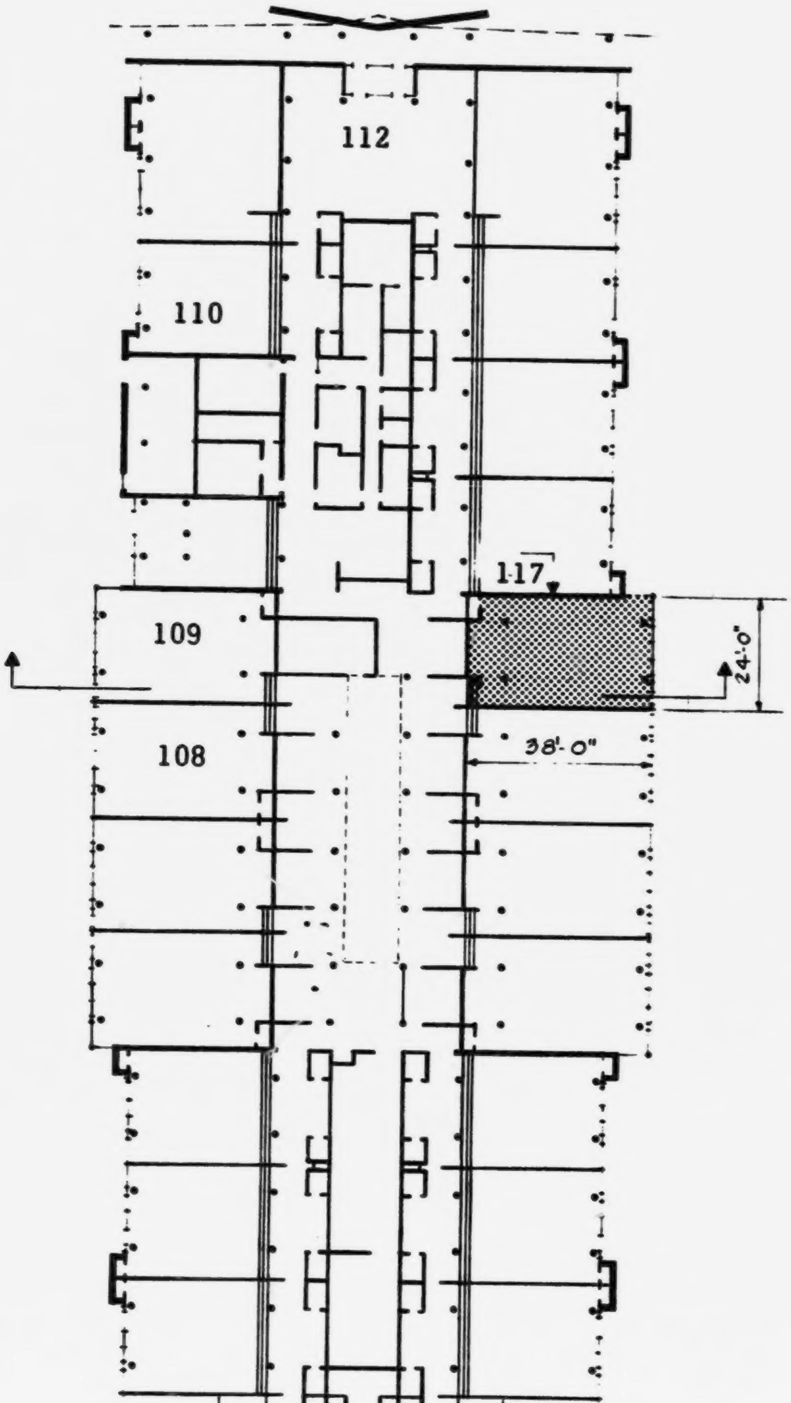
112
110
117
109
108
24'-0"
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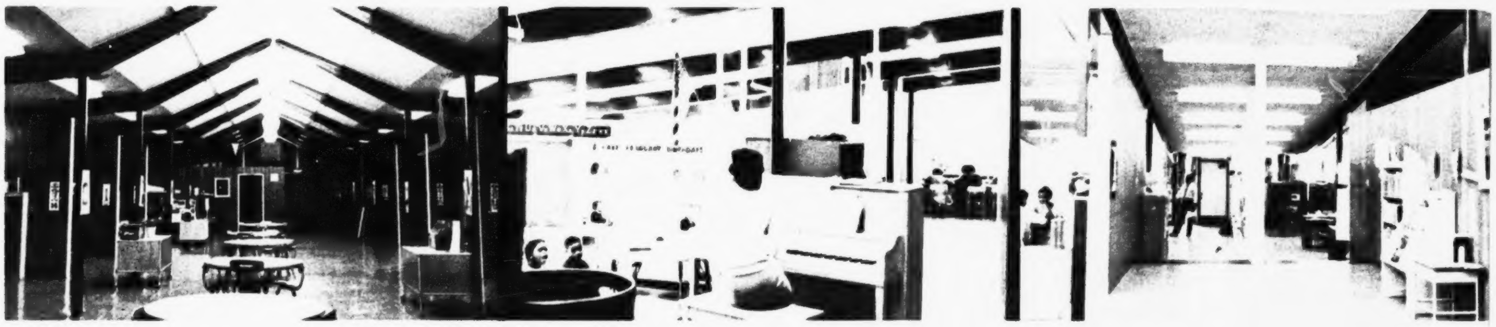
plan



NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
108-109	20	18	21	24	25	24	22
117-109	26	27	26	22	23	24	25
110-112	13	15	15	15	15	16	15

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
108	—	—	7985	.91	.66
109	.01—	65	7985	—	—
112	.01—	64	13880	.91	.76
117	.01—	63	7985	.91	.66

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
112	66	66	64	63	60	61-65	62
108	70	67	66	62	64	61-68	65

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
109	73	69	67	65	65	61-68	64
112	71	68	67	63	61	59-64	61
108	69	65	63	63	64	59-64	61

TEACHER OPINION POLL (%)

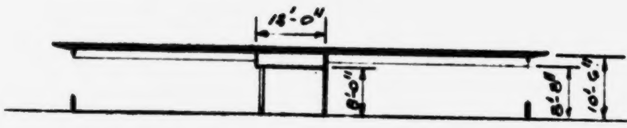
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	12	38	38	12	0

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

Ventilator Noise	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
108	51	41	36	31	27	24

SCHOOL
11
MW

This is a high school using a program of team teaching and large group instruction. Tests were made in two areas: the first was a large room (#79) where television was used to present a subject to a single group of 172 students, after which the instructor offered comments to the entire group. The class then formed into small discussion groups of four to six students, sitting around tables in the same room. In the second area there were three adjoining classrooms in which three teachers were teaching three different classes in different subjects, one of which was typing; there were no doors separating the rooms; the tested room is #88. There was conventional acoustical treatment in all rooms in the form of tile on the ceilings. Teachers were generally disposed to accept the acoustical environment as good and said that they could perform their work adequately. It is significant to note that the acoustical environment in the room used for large classes, Room #79, could have been bettered considerably; yet both students and teachers seemed quite capable of adapting themselves to their environment.



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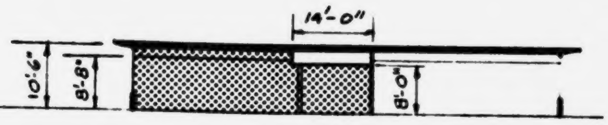

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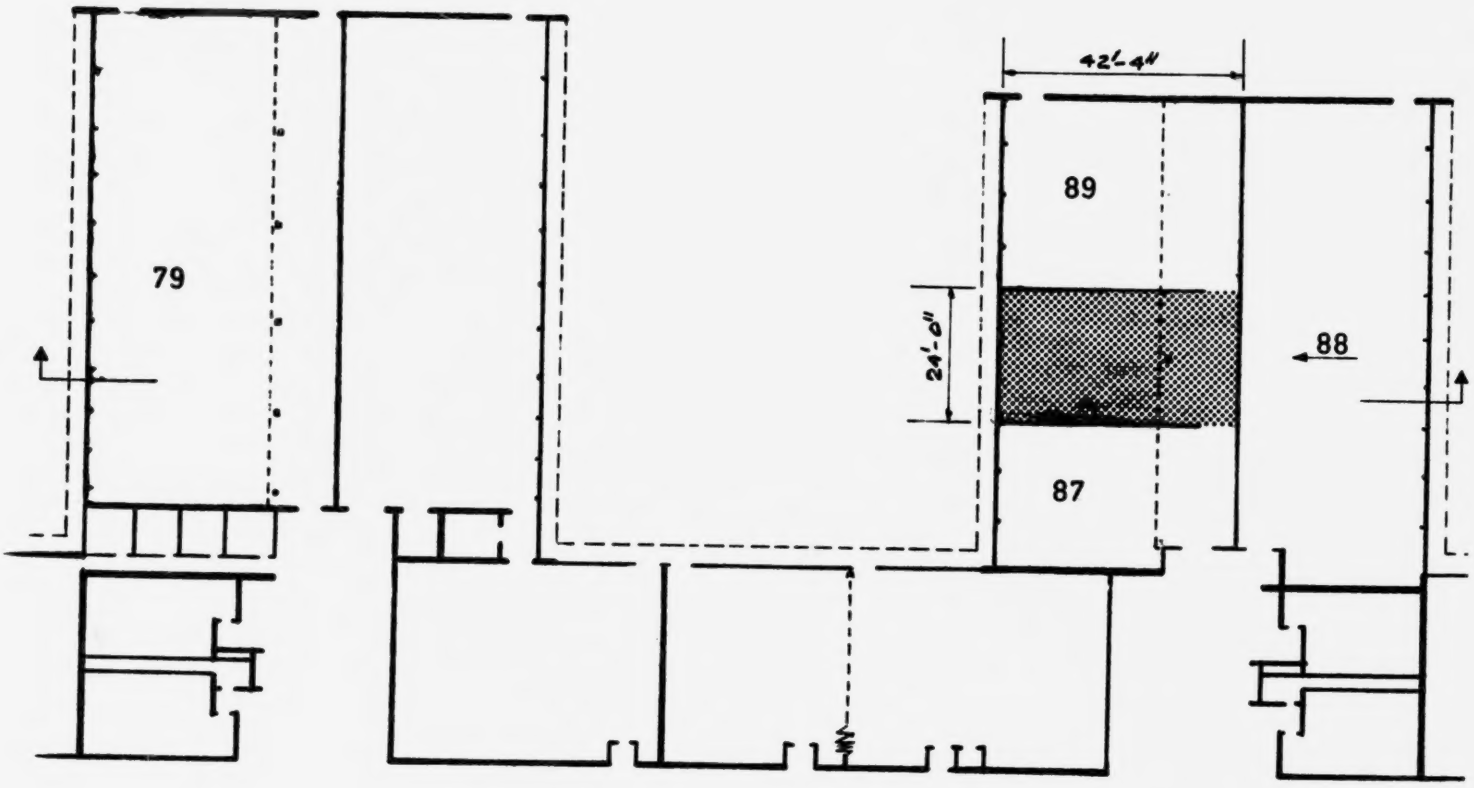


partial plan

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
89-88	10	11	14	17	17	18	14
89-87	20	20	25	16	28	28	23
89-center corridor 88	10	10	12	14	15	14	12

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
87	—	—	9662	—	—
88	.15	40	10110	live	.70
89	—	—	13480	—	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
87	57	59	55	49	47	67-75	69
88	63	63	59	52	50	70-78	74
89	64	63	60	58	60	72-75	73

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
88	55	53	45	39	36	—	—

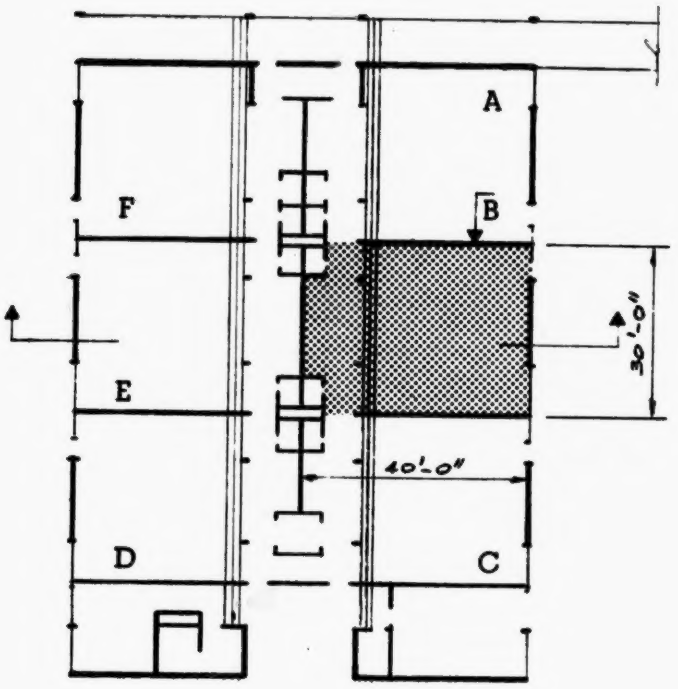
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	22	56	11	0	11

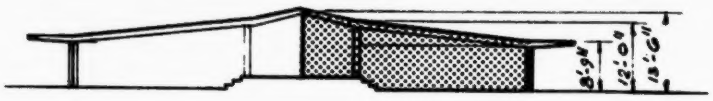
SCHOOL 12

MW

This is an intermediate school which is most attractive and imaginatively designed, architecturally; colors and textures are excellent. Rooms are generally open to each other. When the school was first built, classrooms were open across the cross section; later a glass partition was installed to intercept the transfer of sound. The shape of the cross section is such that the reflection of sound across the building is encouraged. There is a rather wide variation in teacher opinion. One teacher observed that the personal differences of teachers are important in influencing their opinions of the teaching environment. Another teacher says that during classes she can accustom herself to a rather high ambient noise level, but when an adjacent class leaves the room, the relative silence requires another adjustment to the unexpected silence. The noise from neighboring rooms, the sound of record players, the noise of mechanical equipment, and the noise of moving furniture on the asphalt tile floor were listed as elements of distraction. Some teachers had difficulty in understanding the speech of soft-voiced students; others could easily understand speech in adjoining rooms. Of the five teachers who rated the school *unsatisfactory* in the teacher opinion poll, one offered the reason that the number of students per class was too high, the other four named unsatisfactory acoustical conditions. Many of the students said they believed the rooms to be too noisy, and many objected to the noise of moving furniture.



plan



section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
B-A	−2	5	9	15	17	19	10
B-C	4	6	8	14	19	21	12
B-D	10	18	24	31	37	41	27
B-E	6	14	24	35	39	43	27
B-F	9	18	25	32	36	41	27

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
B	.05	50	10750	live	.71

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
B	61	57	55	52	50	68-73	70

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
B	59	53	52	50	49	67-69	68

TEACHER OPINION POLL (%)

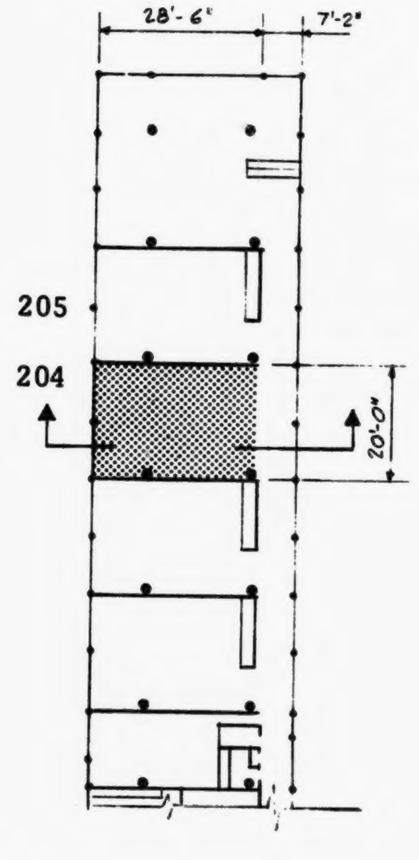
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	22	33	6	11	28

SOURCE OF NOISE Room Empty—School Not in Session (Noise Level in db in Tested Room)

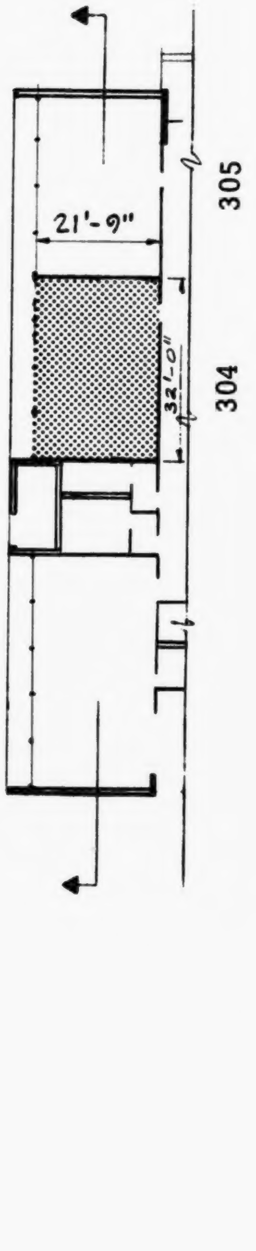
	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps
Mechanical Room as heard in C	71	62	45	40	31	22

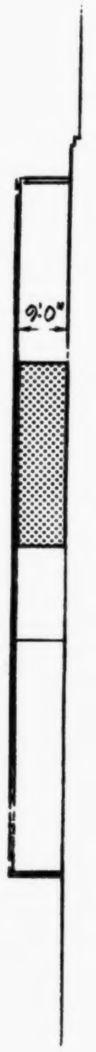
SCHOOL
1
SW

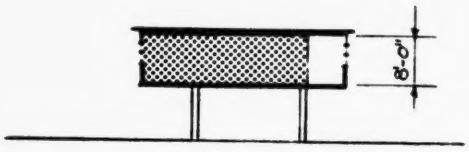
In this high school, one of the classrooms which have been tested, Room 204, is located in a wing-type building with a single-loaded corridor on one side; the exterior wall is glazed. This corridor serves all classrooms. These classrooms are partially screened from the corridor but are acoustically open to it; thus there is no acoustical barrier between classroom and corridor or between classroom and classroom. This building is one of the pioneering examples of open planning and has been in use since approximately 1954. Teachers and students offer some complaint about unwanted sounds from corridor and from neighboring classrooms. One teacher says this about the classroom: "Room has some bad points, but it has one great asset. It is certainly open and lighted. Old traditional rooms now seem boxed in and dreary." This kind of comment from a teacher is rare. Room 304 is located in a building wing constructed later than the previous building wing; it seems that teachers feel acoustically more comfortable in Room 304 than they do in Room 204. The teacher opinion poll contains the opinions of teachers from both kinds of environment.



plan







section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
304-305	14	17	23	27	34	31	24
204-205	13	19	20	22	27	27	20

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
204	.01	45	4560	.50	.56
304	.01–	44	6440	1.00	.62

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
204	54	56	49	48	47	60-70	61
304	56	53	49	48	51	58-73	65

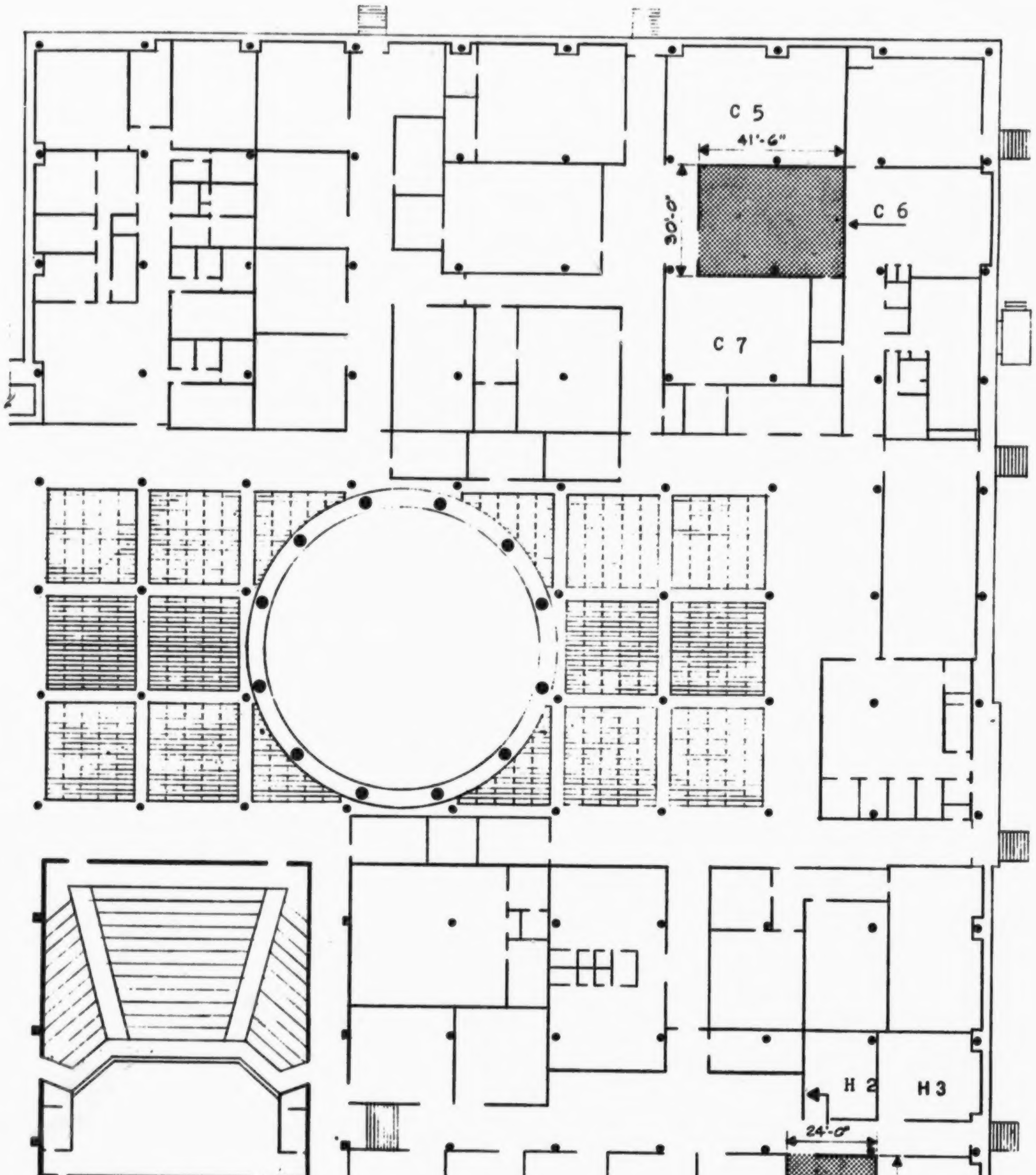
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
204	51	50	46	44	44	57-63	60
304	48	48	46	44	43	55-60	56

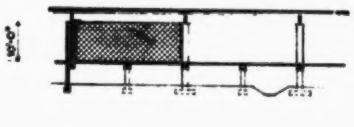
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	0	50	31	19	0

SCHOOL
2
SW


C 5
41'-6"
30'-0"
C 6
C 7
H 2
H 3
24'-0"
K 1
H 6
29'-0"
H 5

partial plan



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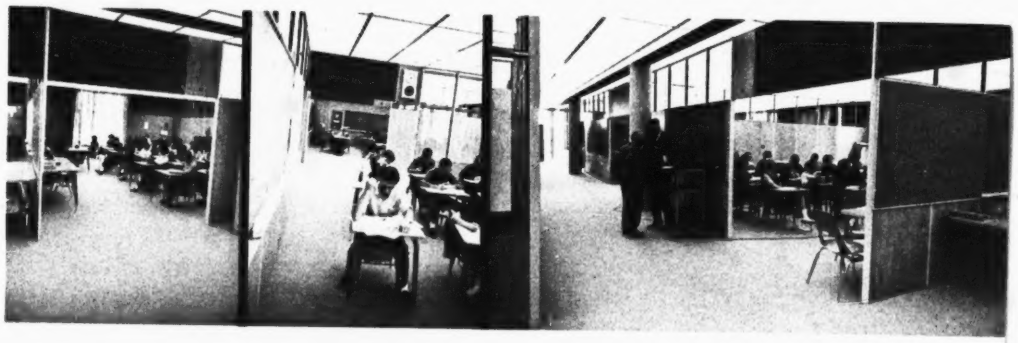


In this high school there is minimal physical separation between classrooms, which are arranged in a large loft area. There is a luminous ceiling throughout, floors of classrooms and corridors are uniformly carpeted, and partitions are made of wood hollow-core doors, splined together to a height of seven feet with glass above. Carpeting was included as a part of the building contract, and its acoustical properties were incorporated in designing the classroom environment. Outside windows are minimum in area. There are no doors between classrooms, and openings are about nine feet wide into each classroom. Teachers are aware of sounds in adjoining rooms, particularly the sound of voices in discussion groups. Teachers comment that they try to keep voices of students as low as possible. Some teachers wished that doors had been provided in the design. Students also are aware of talking in adjacent rooms. Both teachers and students comment about the noise of chalk when used to write on chalkboards. This is a new building and was in the fifth month of use when tested. Comments were generally favorable about the environment. In spite of the fact that classrooms are virtually without acoustical separation and therefore open to each other, there is a feeling of quiet in this environment.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
(uncarpeted) C5-C6	17	18	20	23	21	21	19
C5-C7	20	22	21	24	23	21	22
(carpeted) K1-H6	13	15	21	20	23	25	19
K1-H2	23	21	33	31	27	22	26
K1-H3	25	27	41	30	32	31	32
K1-end of corridor	23	26	33	31	27	24	27

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
H6	.01–	49	7080	.65	.64

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
H6	60	59	57	54	50	60-70	65

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

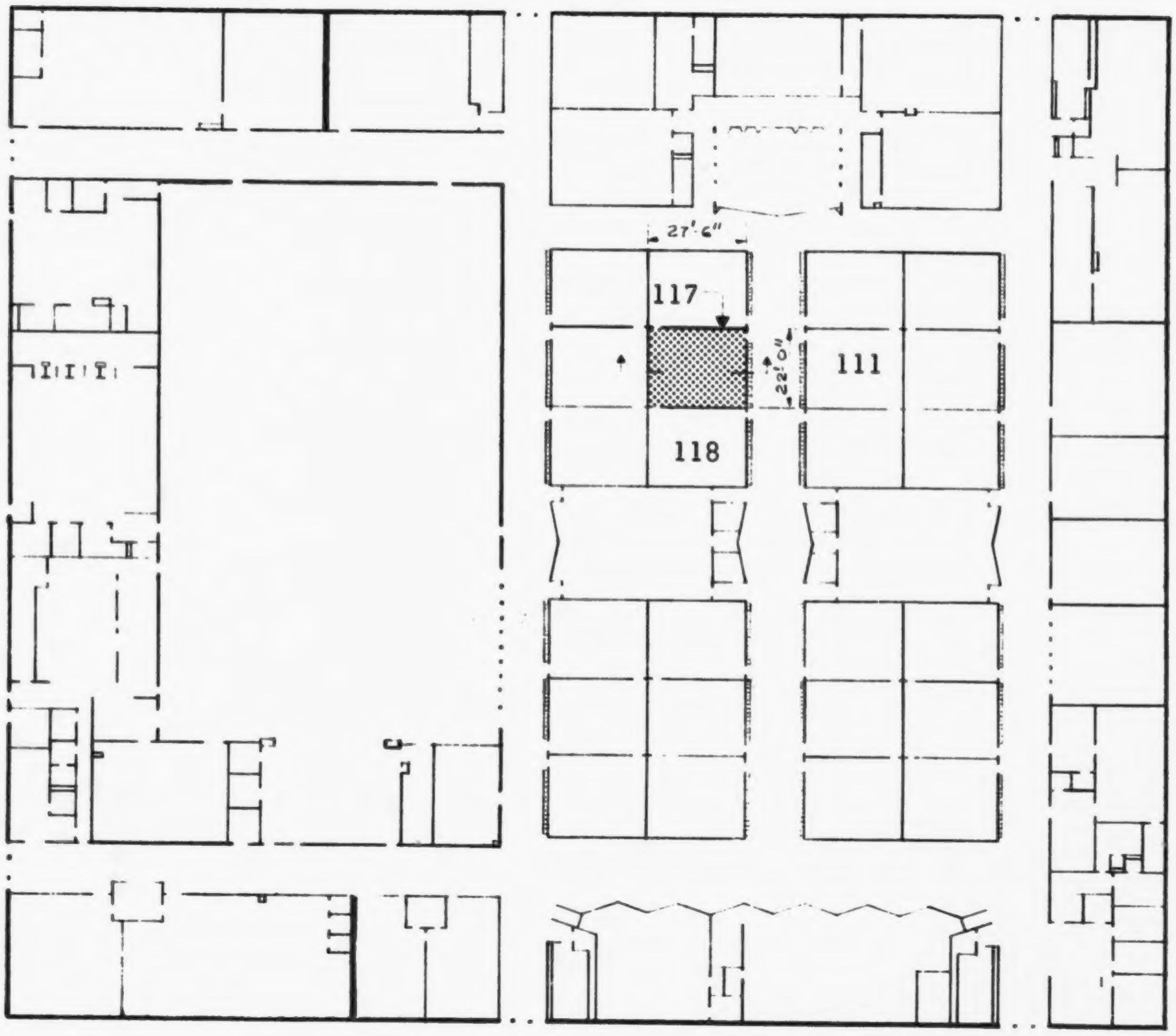
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
H6	54	52	50	49	48	57-60	58

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	60	33	7	0	0

SCHOOL
3
SW

This is a new, large high school where the plan is a large loft area and where the classroom tested was surrounded on all sides by other classrooms. This is the only school in the survey where the teacher opinion poll revealed a 100% rating of *excellent*. All classrooms adjoin corridors which carry a heavy traffic load, and many teachers habitually leave corridor doors open. It should be noted that opinions incline generally to those of approval because of the newness of the plant and the novelty of the new environment. Teachers are aware of the unwanted sound of outside voices and mechanical equipment but raise no objection. Students mention similar unwanted sounds and similarly do not object. Administrators pronounce the environment good.



plan

section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
118-117 doors open	15	16	18	21	24	21	19
118-117 doors closed	10	13	21	23	26	24	20
118-111 doors closed	25	36	44	49	49	48	42
118-111 doors open	18	22	23	24	27	26	23

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
117 door open	.01–	57	5350	.96	.59

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
117	65	62	60	57	53	65-77	71

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

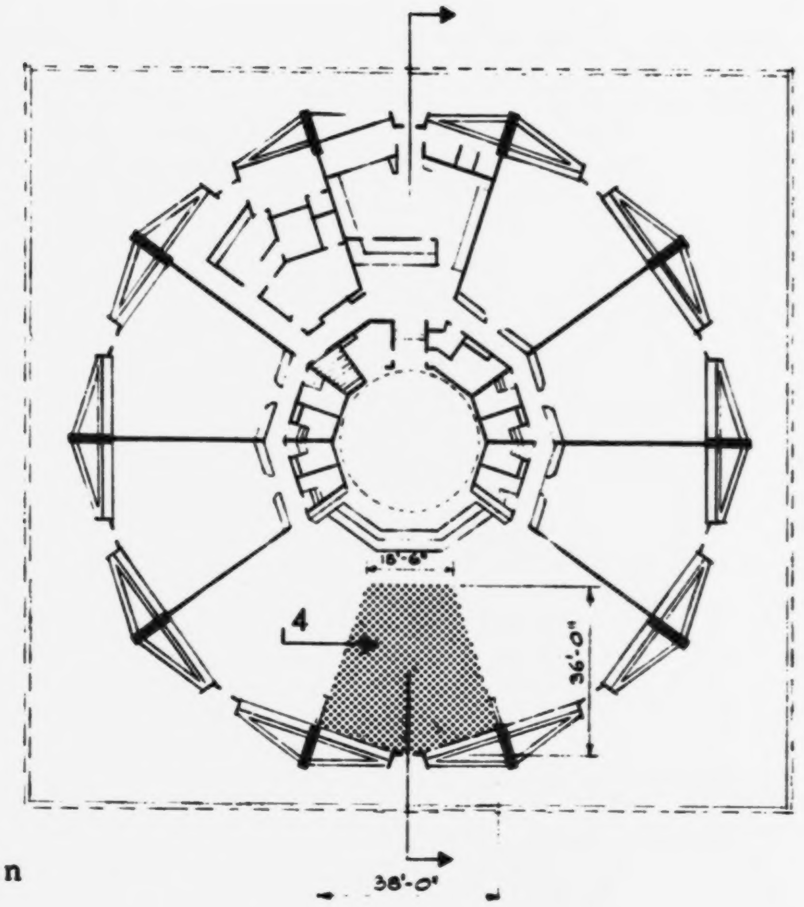
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
117	64	65	62	56	53	69-69	69

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	100	0	0	0	0

SCHOOL
4
SW

This elementary school building has a circular shape which contains the classrooms and is covered with a roof which is square in plan shape. At the center of the plan is an assembly platform surrounded in part by a series of service rooms. Around this core of service rooms is a passageway affording communication between rooms, and since there are no passageway doors, the rooms are open to each other. Acoustical baffles are intended to provide some sound interception. The building is air-conditioned. The platform area is used for dining. One area in the plan is used as an assembly hall with the platform serving as a stage. This assembly room may be divided into three classrooms by means of operable partitions. The tested room was in the center of the assembly area and is thus bordered by two operable partitions. Teachers generally believe the environment to be noisy and somewhat distracting. Sounds from neighboring classrooms and during the lunch period are mentioned as distractions. The principal reports, "The noises are not to the extent that regular classroom instruction is interfered with."



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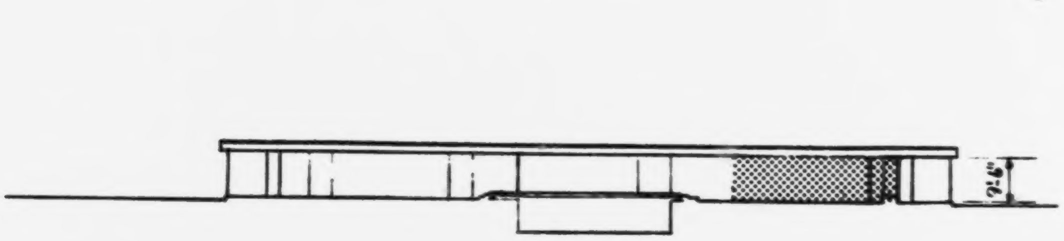


section

NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
3–4	17	19	19	20	22	23	20

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
4	.01–	46	8850	.91	.68

CLASS IN SESSION (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over–all Range cps	Average
4	55	56	56	47	45	57–70	65

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over–all Range cps	Average
4	51	49	48	45	46	58–62	60

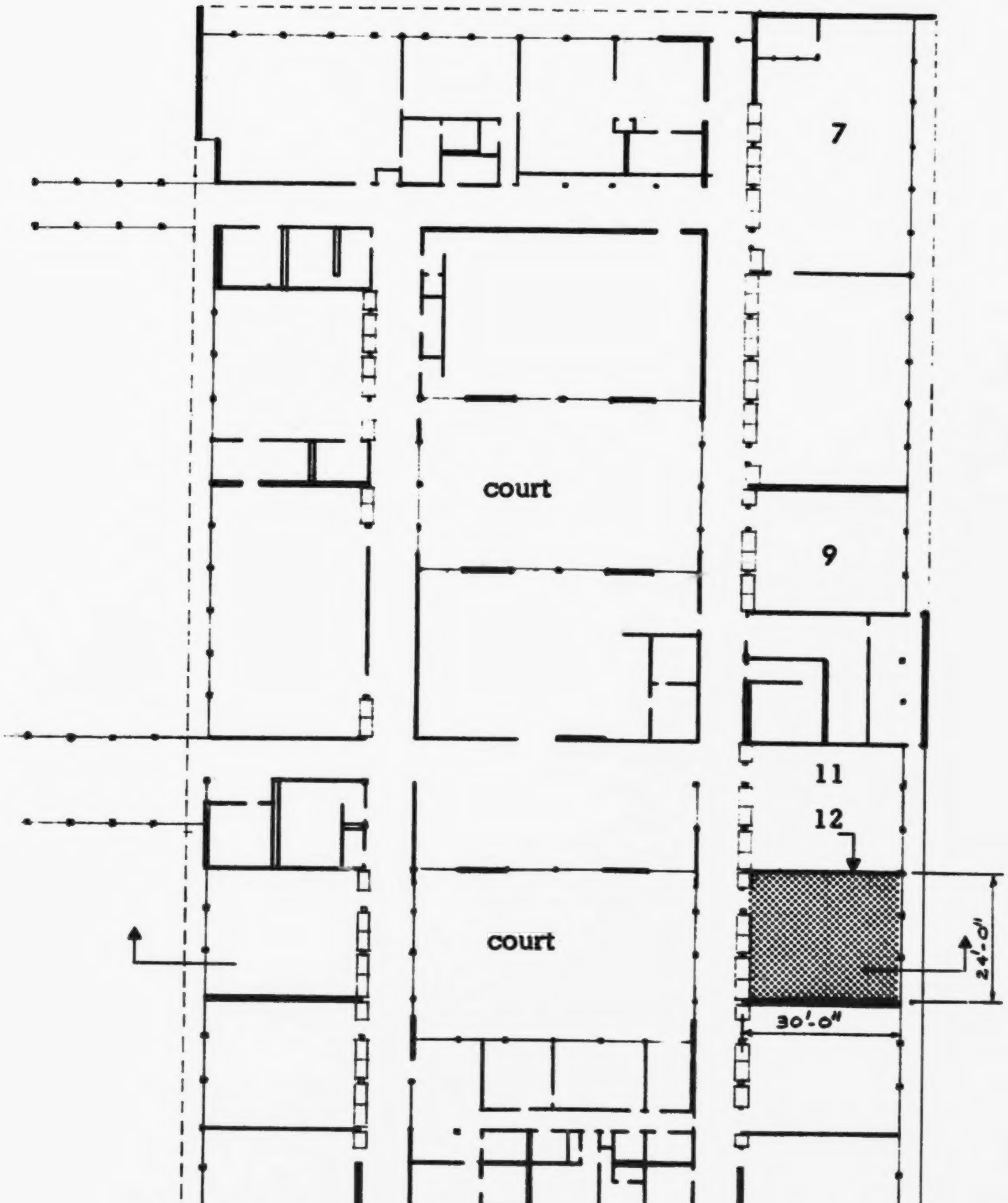
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	0	9	64	27	0

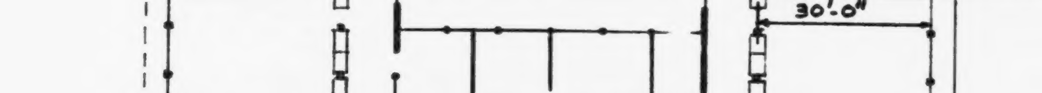
SCHOOL

5

SW


7
court
9
11
12
court
24'-0"
30'-0"

plan



section

This is a school which houses the high school grades. In this design the classrooms are served by a corridor and are screened from the corridor by a partition of storage units which are open at the top and bottom; thus there are no sound intercepting elements between the classrooms and corridor. The teacher opinion poll was not obtainable from this school at the time the survey was made; it was obtained later from only one teacher, who rated the environment *good*. This means that one of the most useful units of measurement and comparison is missing from this school. The openness of the plan meets with widely varying reaction from the teachers as shown by the following two comments: (1) "...in every room you can be taught by five other classes...noise goes through the walls like there was nothing there at all." (2) "Ceiling material mutes noises so that they do not offend, even though they can be heard.... Sounds from adjoining room are seldom intelligible except for very distinct records used by French and English classes." Student opinions likewise vary.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
11-12	15	20	23	27	32	34	25

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
12	.01	42	6590	.51	.63
7	—	45	—	—	—
9	—	47	—	—	—

CLASS IN SESSION (Noise Levels in db)

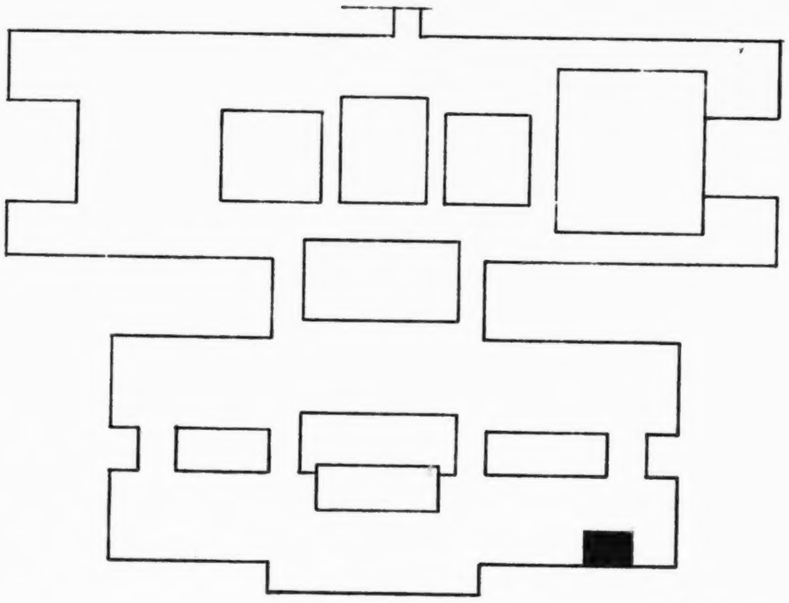
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
12	51	50	50	48	48	50-65	59
7	55	61	59	54	51	60-67	64
9	53	54	51	51	51	63-70	68

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
12	56	54	46	45	49	52-68	54
7	56	54	52	51	51	58-61	60
9	51	45	44	44	46	63-67	64

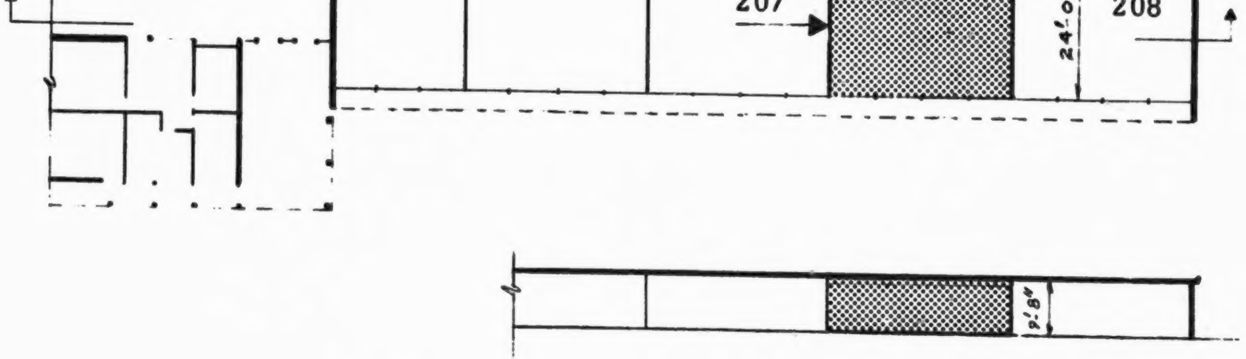
SCHOOL
6
SW

The significant feature of the typical classroom of this school is the use of jalousies for ventilation on the corridor wall. At the top of the partition, glass jalousies extend from door head to ceiling. At the bottom of the partition wood jalousies approximately 2' 1" high are placed on a 5 3/4" curb totaling 2' 6 3/4" in all above the floor. Both sets of jalousies are adjustable. Tests were made when classrooms were in session in the four adjacent rooms, and corridors were subject to normal between-class traffic. Teachers reported that classroom doors were generally left open; that noises from the classrooms represented occasional, not continual, distractions. Jalousies were characteristically partially open in nearly every classroom. Students were generally satisfied with the environment.



key plan

partial plan



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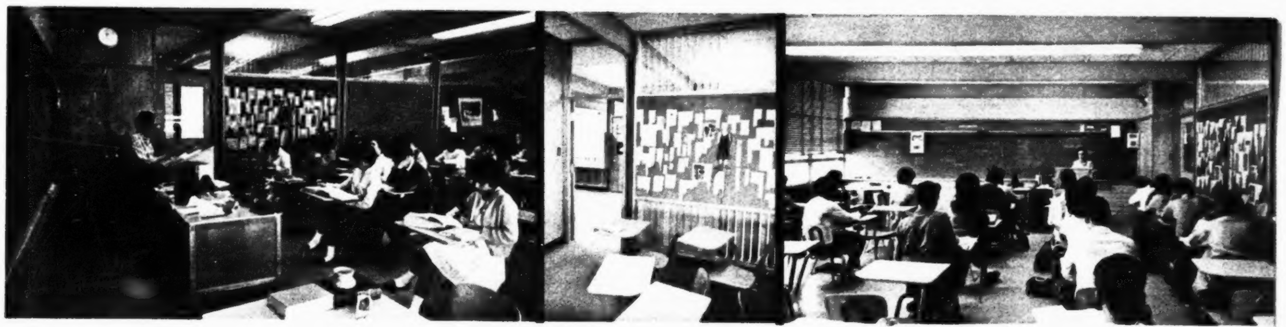


NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
208-207	18	17	21	24	26	29	22

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
207	.01–	48	7420	.71	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
207	68	63	57	51	50	72-77	74

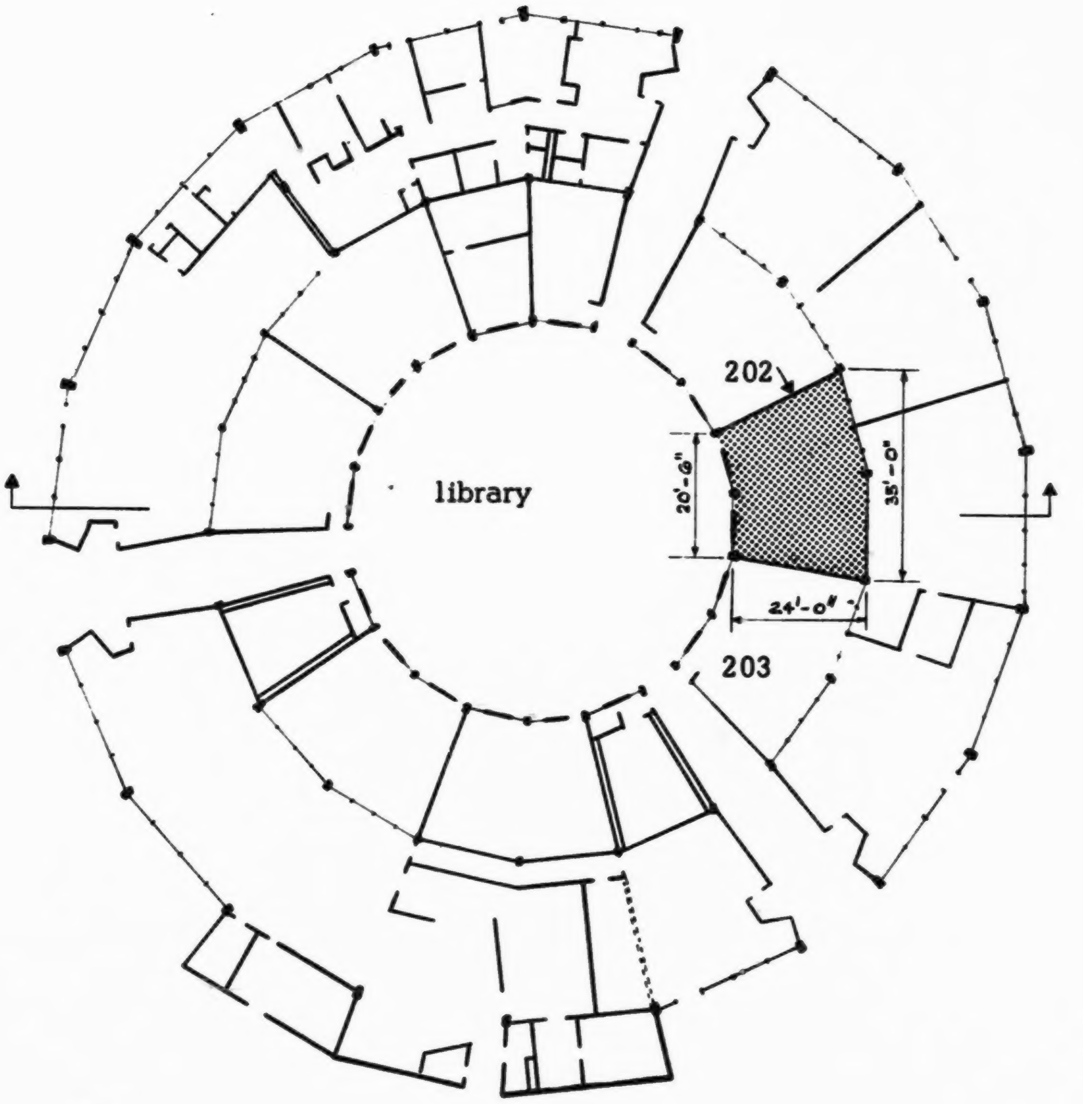
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
207	64	56	31	48	46	65-65	65

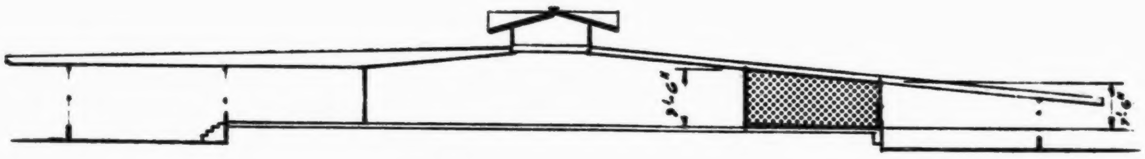
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	60	30	10	0	0

SCHOOL
7
SW


202
library
20'-6"
35'-0"
24'-0"
203

plan



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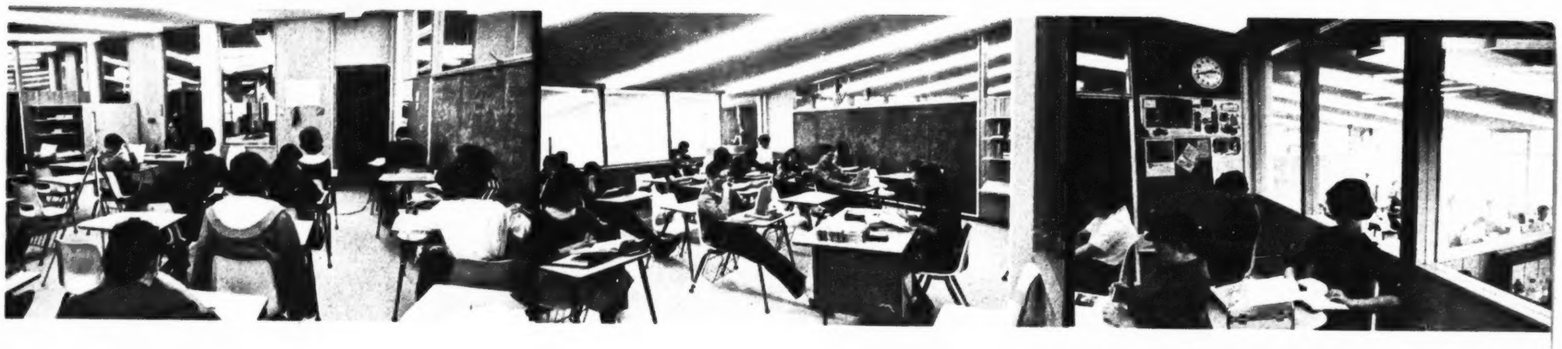


This is a high school which is circular in plan; the center of the circle is the library, which is surrounded by an inner circle of classrooms at the same floor level; there is a concentric outer circle of classrooms, cafeteria, and administrative offices at a lower floor level. The whole is covered by a conical roof. Teachers and students generally spoke well of the acoustical environment; only one teacher seemed to object somewhat to ventilation system noise. The major criticism seemed to be the shape and location of chalkboards, which we assumed indicated no complaint about the acoustical environment. Most teachers allowed the door between the classroom and the library to remain open most of the time.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
203-202	16	20	28	32	35	36	28

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
202	.03	34	6940	1.01	.64

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
202	57	54	51	47	46	56-63	59

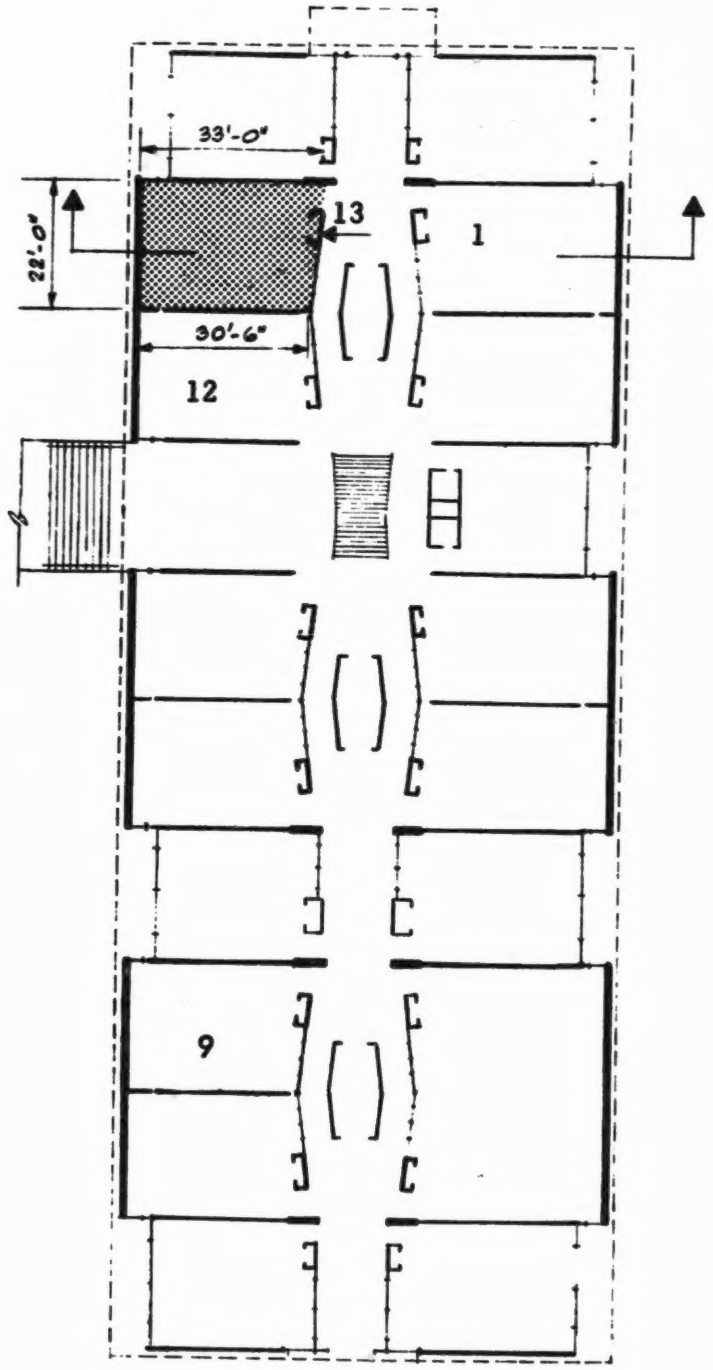
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
202	41	38	35	33	33	50-55	52

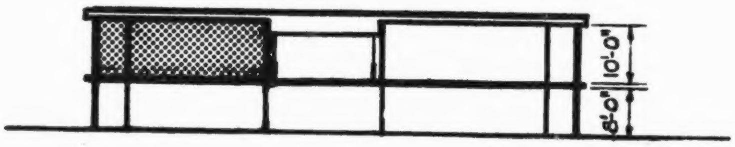
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	11	56	33	0	0

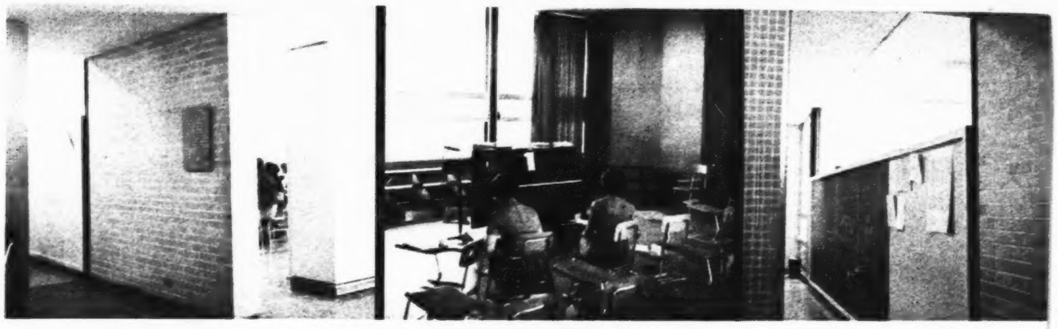
SCHOOL
8
SW


33'-0"
22'-0"
30'-6"
13
1
12
9

plan



section



This high school plant consists of a number of separated building wings; the wing in which the tested classroom is located is two-story at one end and single-story at the other, thus fitting itself to a sloping site. The tested classroom is located in the two-story portion of the building. There is a central corridor of varying width, with mechanical rooms located at points of greatest width. The corridor ceiling is lower than that of the classrooms. It is interesting to note that there are no doors separating the classroom from the corridor; the opening is 4' wide and extends to corridor ceiling. Partitions between classrooms are glass above a height of 6' 6". Walls between classrooms and the corridor are glass except for short, solid sections near classroom entrances. Teachers and students complain of sounds from the corridor through the opening and sounds from the next room through the glass portion of the partition. Many students say that they are not bothered by noise and offer quite favorable comments on this "pleasant school." Almost everyone seems to want a door at the corridor.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
13-12	11	16	17	20	23	24	19
13-1	16	18	18	20	20	21	19

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
9	.06	41	6985	1.00	.64
13	—	—	6985	1.03	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
9	58	54	50	47	45	57-72	63

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
9	52	46	43	40	40	53-62	58

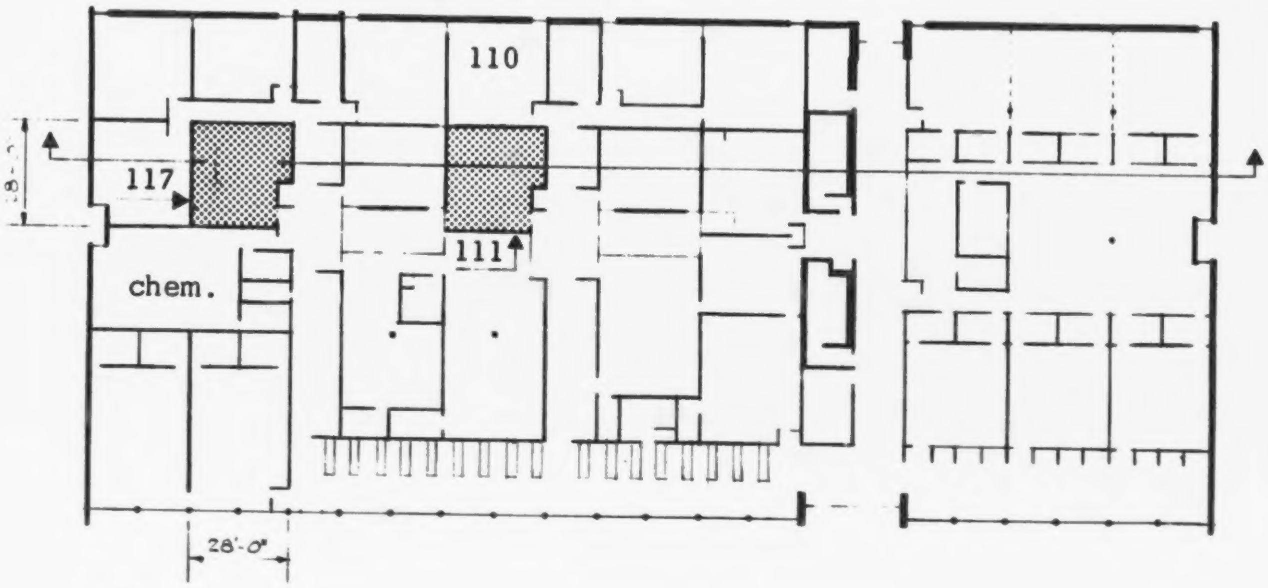
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	10	45	35	10	0

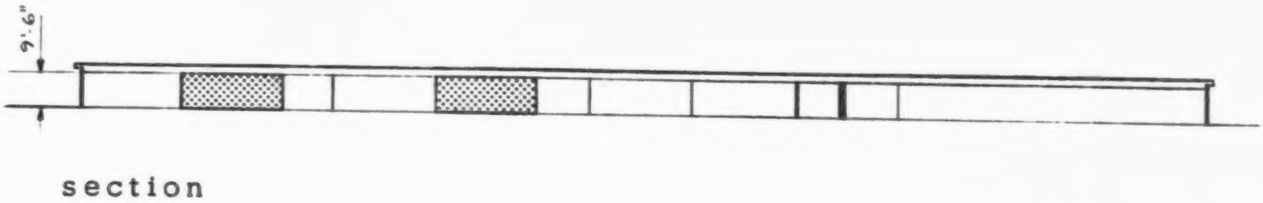
SCHOOL
9
SW

This is a single-story high school facility. The plan shows a compact, loft-type classroom area in which many classrooms are located on the interior where three partitions are common to other classrooms; the fourth partition usually separates the classroom from an adjoining corridor. Some of the corridors contain student lockers. In the tested classroom (110-111), two partitions are common to adjacent classrooms; the remaining two partitions separate the classroom from adjacent corridors; one of these corridors contains student lockers. Generally the partitions are glass above door height, and in the tested classroom there are glass jalousies in two walls, one of which vents into a corridor, the other into the adjacent classroom.

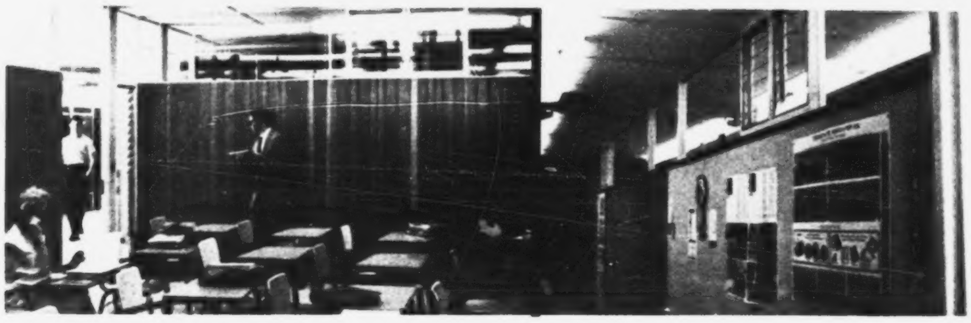
The *not acceptable* rating reflected opinion on space or equipment not related to acoustical environment, except for one opinion which commented unfavorably on the sound transmitted through a folding partition. Teachers notice that sound from adjacent rooms is heard in classrooms. Students are aware of unwanted sound and comment that it is a distraction when taking a test.



plan



section



NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
110-111	19	28	27	27	30	29	27
Chem-117	18	28	29	34	37	35	30

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
110	—	—	8130	1.00	.64
117	.01—	42	7320	—	—
111	.01—	46	7320	—	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
117	56	55	52	48	46	57-68	62
111	53	53	51	48	48	58-61	59

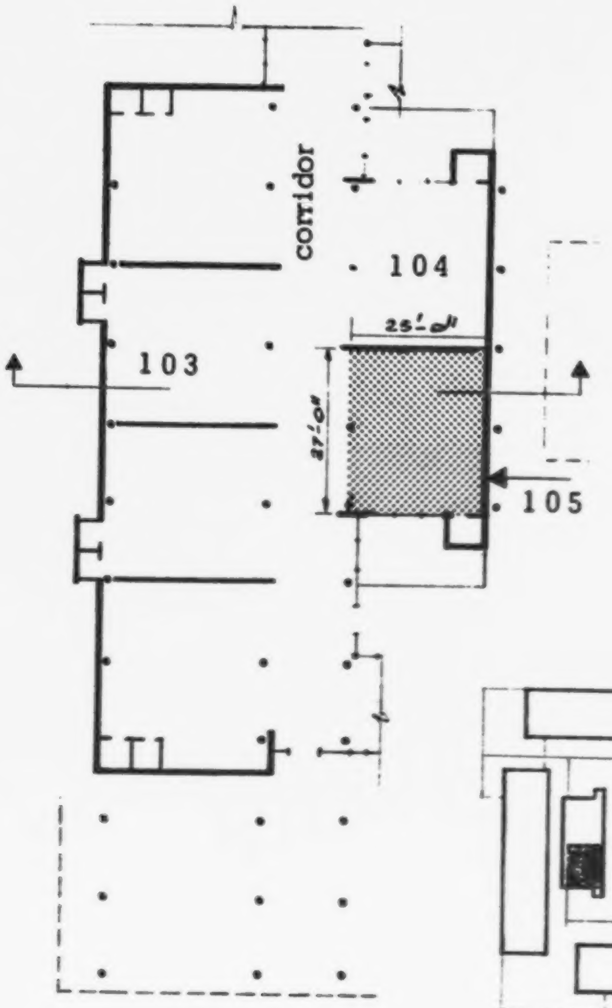
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
117	45	44	43	42	42	57-60	58
111	49	48	47	46	46	57-60	58

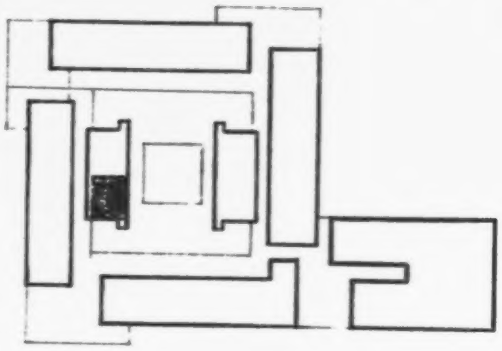
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	33	33	0	17	17

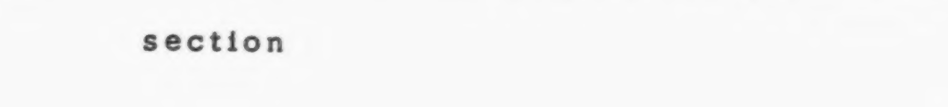
SCHOOL
10
SW


corridor
104
25'-0"
103
27'-0"
105

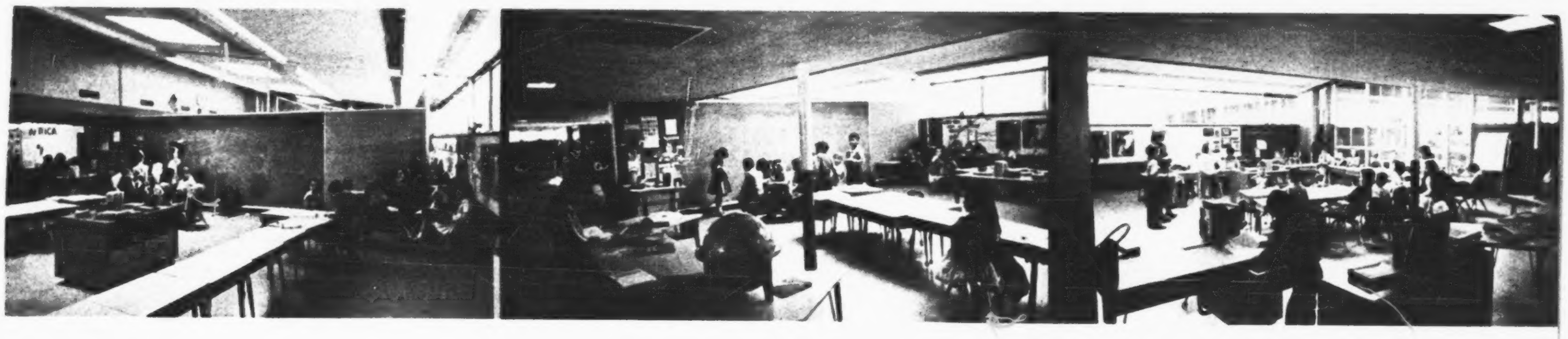
partial plan



key plan



section



This elementary school is an example of teaching space where there is virtually no separation, either acoustical or physical, between classes. The ceiling slopes from a high point at the interior passageway downward to a low point at the outside wall. There is a dropped ceiling over the passageway, and the space above houses ducts and mechanical equipment. There are partitions between classrooms which are solid to door height and continuous glass from this height to the ceiling line. Along the passageway there is no partition at all, and classrooms on opposite sides of the passageway are open to each other. Movable cabinet work is sometimes arranged to provide a partial sight screen between classroom and passageway, but these are quite often moved. Almost all teachers not only comment favorably but are enthusiastic about the environment of the school, which has been in use for about six years. The teachers feel that the openness encourages freedom in class groupings and in the use of space. Teacher: "When we first moved in this building, I noticed the children adjusted to it much faster than the teachers." Principal: "The acoustical environment is splendid. The fourth (classroom) wall was omitted, yet this building is quieter than the ordinary."

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
105-103	20	17	21	21	23	22	21
104-105	24	23	29	28	34	33	28
105-corridor	16	14	18	14	15	14	15

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
103	.01–	51	7250	live	.65

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
103	56	55	54	50	50	58-73	6[illegible]

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

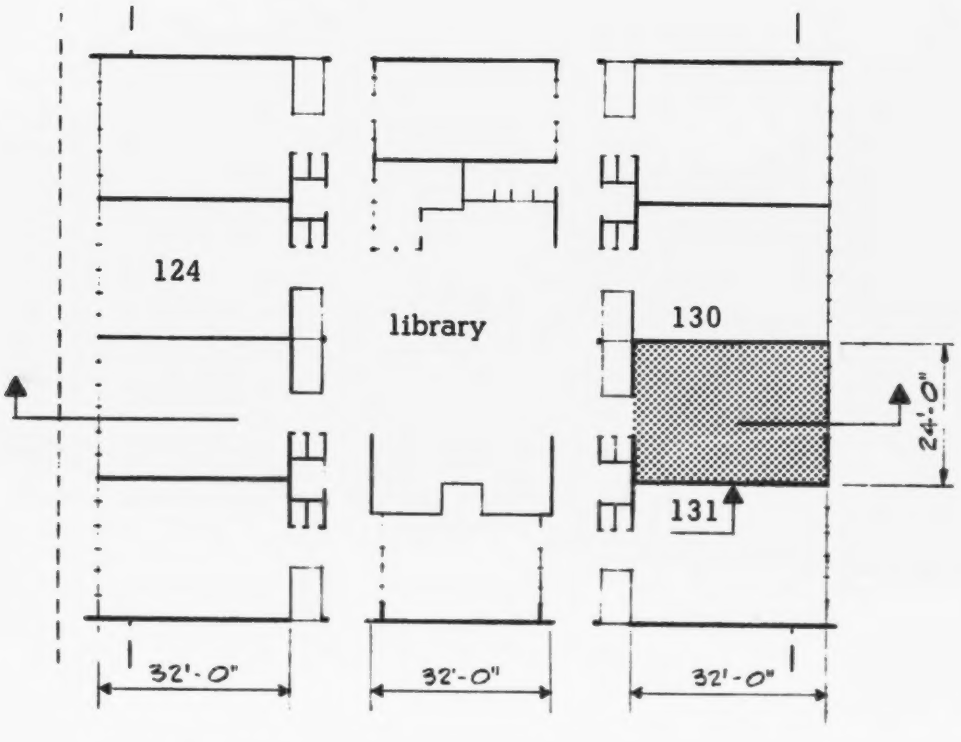
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
103	57	55	53	49	50	45-70	61

TEACHER OPINION POLL (%)

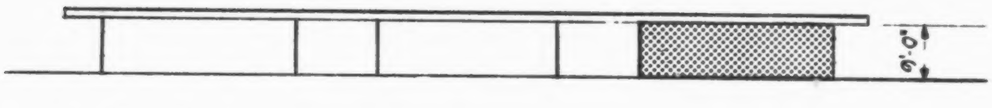
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	50	43	7	0	0

SCHOOL
11
SW

This is an elementary school where the classrooms, 24' × 32', are positioned with the narrow end open to a passageway, with low cabinet work the only separation. Continuous windows are along the outside wall. In the center of the building wing are special classrooms, meeting rooms, conference rooms, and service and storage areas, except at the library, shown in the plan. At the library, the building is completely open, from outside wall to outside wall. The ceiling is flat and nine feet high. Most of the teachers say that they like the acoustical environment, although they are aware of interfering noises from adjacent areas, mostly voices. The principal comments that the special classrooms in the center portion of the school used for special reading classes and speech therapy, together with the library, present special problems of interfering sounds, because the sound comes from two sides.



partial plan



section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
Rm. 124-131	21	19	19	19	24	25	21
Rm. 130-131	16	22	27	27	31	32	26
Library-131	13	14	15	15	18	19	16

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
131	.01–	51	7200	live	.65

CLASS IN SESSION (Noise Levels in db)

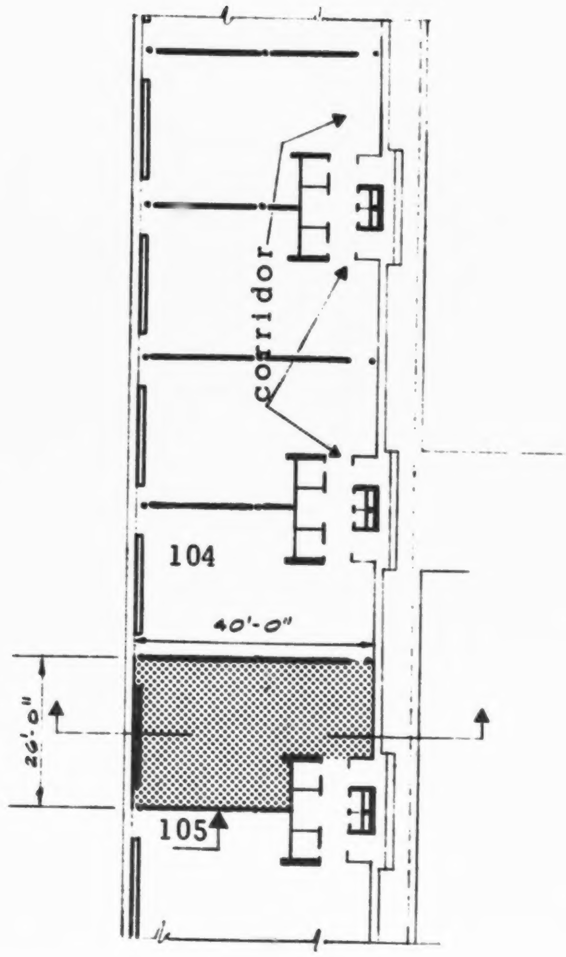
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
131	56	50	50	45	48	55-70	64
124	54	54	53	49	45	59-70	63

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

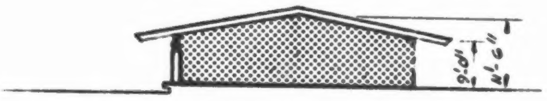
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
131	56	57	53	51	50	56-68	61

TEACHER OPINION POLL (%)

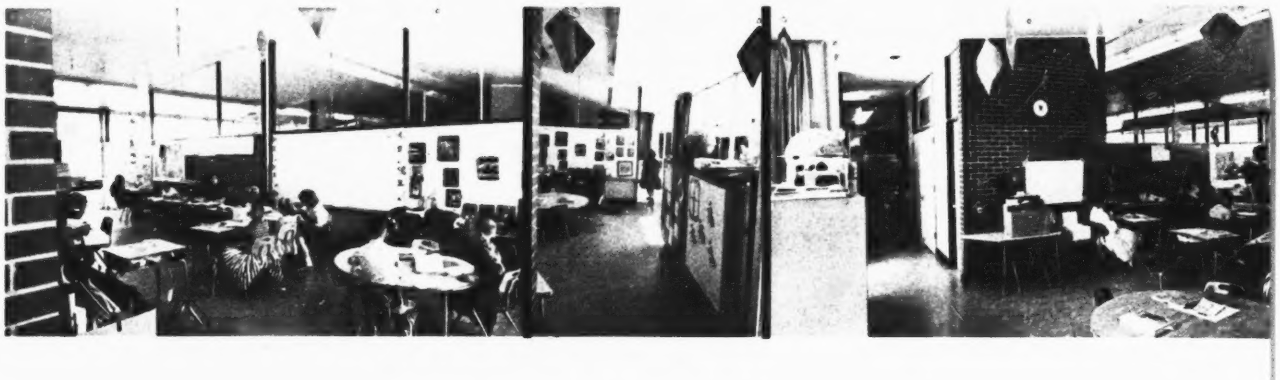
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	11	33	56	0	0


corridor
104
105
40'-0"
26'-0"

partial plan



section



This is a pleasant school with a sloping roof whose ridge is at the center. There are windows on opposite outside walls, and the partitions between classrooms are generally solid to door height, with continuous glass to the ceiling line. On alternating partitions toilet-storage areas are located; there are openings from one classroom to another, either through the partition or through the toilet-storage area; hence classrooms are partially open to each other, and the passageway through these openings serves students and teachers as a corridor. Even with an opportunity to walk the length of a building wing through classrooms, there is generally very little traffic. Teachers comment that rooms are not quiet, but they have learned to work in an environment with a higher noise level than is true of more conventional rooms. Some teachers attempt to keep the voices of children down because they do not wish to create an interference to neighbors. Other teachers are careful to group students in a compact pattern in the room so that the teacher's voice will easily reach the extremity of the group. Teachers judge the working environment good.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
104-105	12	13	15	17	18	19	16
104-corridor	6	17	17	21	4	2	16

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
104	.04	47	9843	live	.70
105	.04	47	—	—	—

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
104	56	53	53	52	52	57-67	63

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

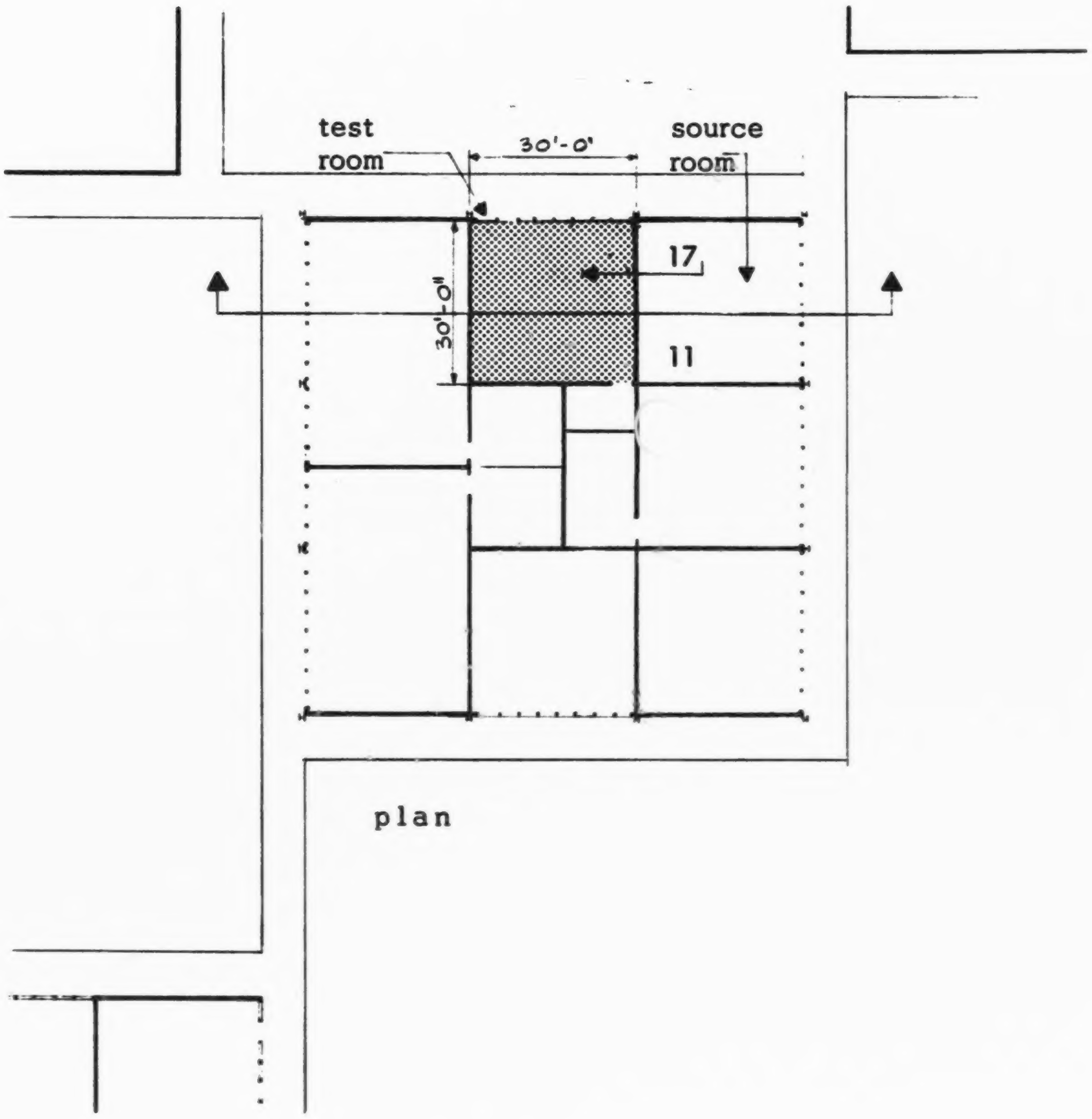
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
104	51	49	49	45	46	53-65	59

TEACHER OPINION POLL (%)

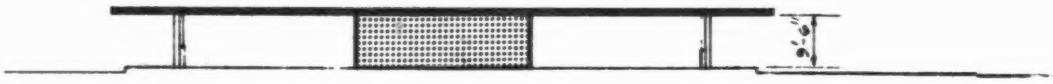
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	27	47	26	0	0

SCHOOL
1
PC

The room tested in this high school is located in a compact building wing; it is flanked by two adjoining classrooms in the wing. The corridor surrounding the building is open. Adjacent wings form a checkerboard pattern in plan, thus no adjacent building wing presents an opposite wall. Each classroom has continuous curtain wall windows from floor to ceiling; the lower lights are filled with solid panel. The plant is new and was in its second year of use when tested. Teachers comment that sound films and record players in adjacent rooms can be heard; a few teachers say that noise from the outside corridor intrudes. Students are aware of unwanted sounds coming from talking in the outside corridor and from a work room at the center of the building; a few students notice sound from A-V equipment in adjacent classrooms.



plan



section

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
11-17	27	30	35	42	41	43	38

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
17	.01–	44	8550	.82	.67

CLASS IN SESSION (Noise Levels in db)

	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
17	61	61	57	53	50	70-78	75

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

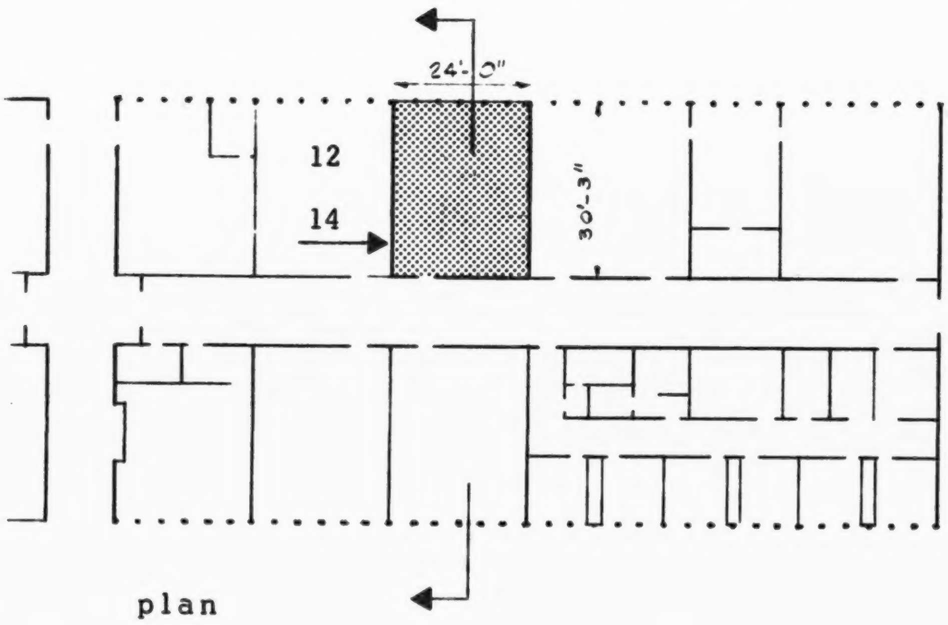
	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Over-all Range cps	Average
17	51	49	45	44	44	68-68	68

TEACHER OPINION POLL (%)

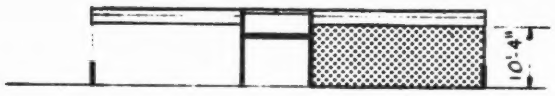
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	33	33	22	12	0

SCHOOL
2
PC

This is a school plant at the college level; the room tested was located in a building wing, and running down the center was a double-loaded corridor with classrooms on both sides. This building is not in any way an open plan; classrooms are acoustically isolated from each other. The outside wall of each classroom was provided with continuous vision strip windows, and between classrooms was a solid, full-height partition; the corridor wall of each classroom was also a full-height, solid partition. The door from classroom to corridor was solid without window light or transoms. Teachers report that they are generally content with the environment of rooms; teachers expressed mild complaint about noises from the hallway and from record players or sound films in adjacent rooms. Several teachers commented on noise distraction caused by lawn mowers outside the building. Students were generally satisfied with room conditions but some mentioned unwanted sounds from corridor and noise of sweepers and lawn mowers outside building.



plan



section

NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
12–14	23	30	35	40	38	44	35
Corridor outside 14–							
to 14, door closed	25	24	27	29	26	25	26
to 14, door open	13	14	10	11	9	9	11

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
14	.01–	48	9430	.84	.69

CLASS IN SESSION (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
14	60	60	55	54	50	62–74	68

STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

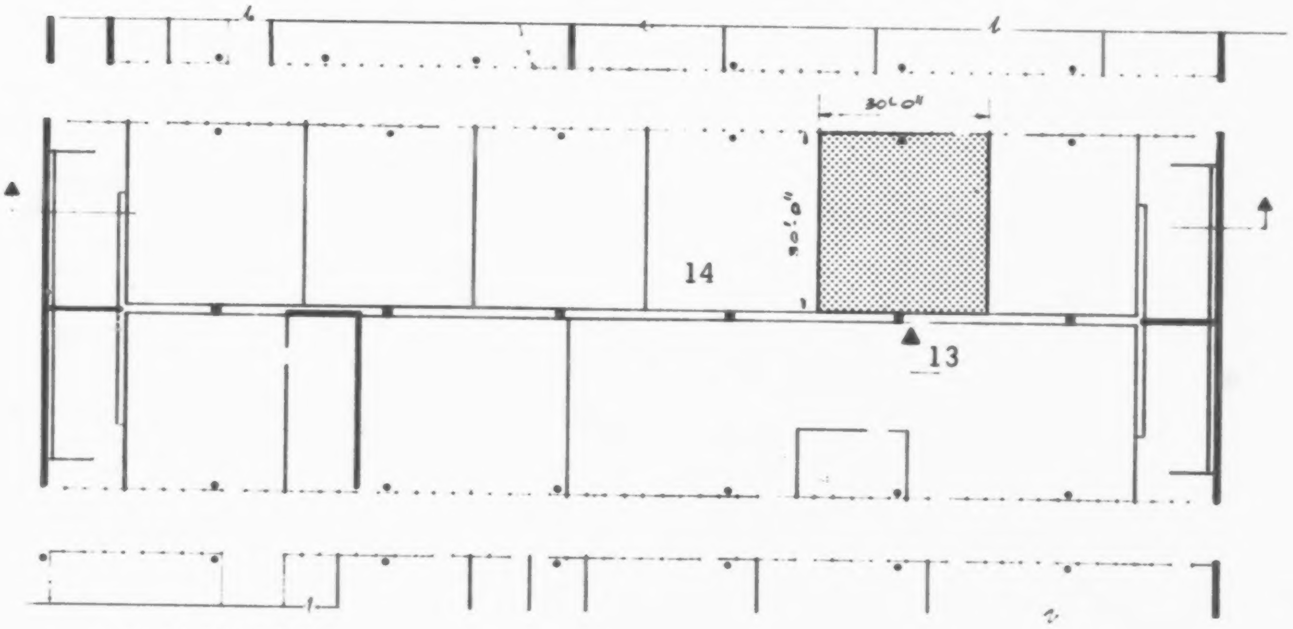
	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
	54	52	49	48	47	62-63	62

TEACHER OPINION POLL (%)

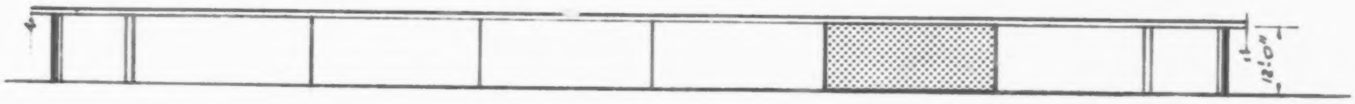
	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	33	17	33	17	0

SCHOOL
3
PC

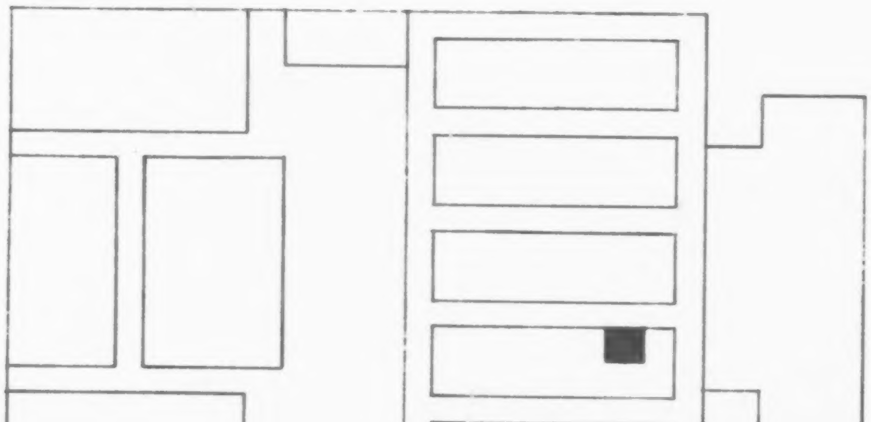
This is a high school whose plan characteristic is a large, compact, loft-plan area. The tested classroom is in the center of a group of classrooms; it is an interior classroom without contact with an outside wall. Most complaints seemed to be directed at the noise produced by the mechanical ventilation system and temperature control problems. A few teachers commented that it was at times difficult to understand the words of students when reciting or in discussions; others complained that they had to speak more loudly than normal to be understood by students. Student comments corresponded to those of the teachers with special emphasis on the noise of the ventilation system. Teachers and students objected to the sound of music from the music classrooms penetrating the classroom area.



partial plan



section



key plan

NOISE REDUCTION (NR) in decibels (db)

	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Average 75–4800 cps
14-13	20	37	43	43	36	38	36

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
13	.01–	47	10800	1.19	.71

CLASS IN SESSION (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
13	63	64	56	55	51	55-81	71

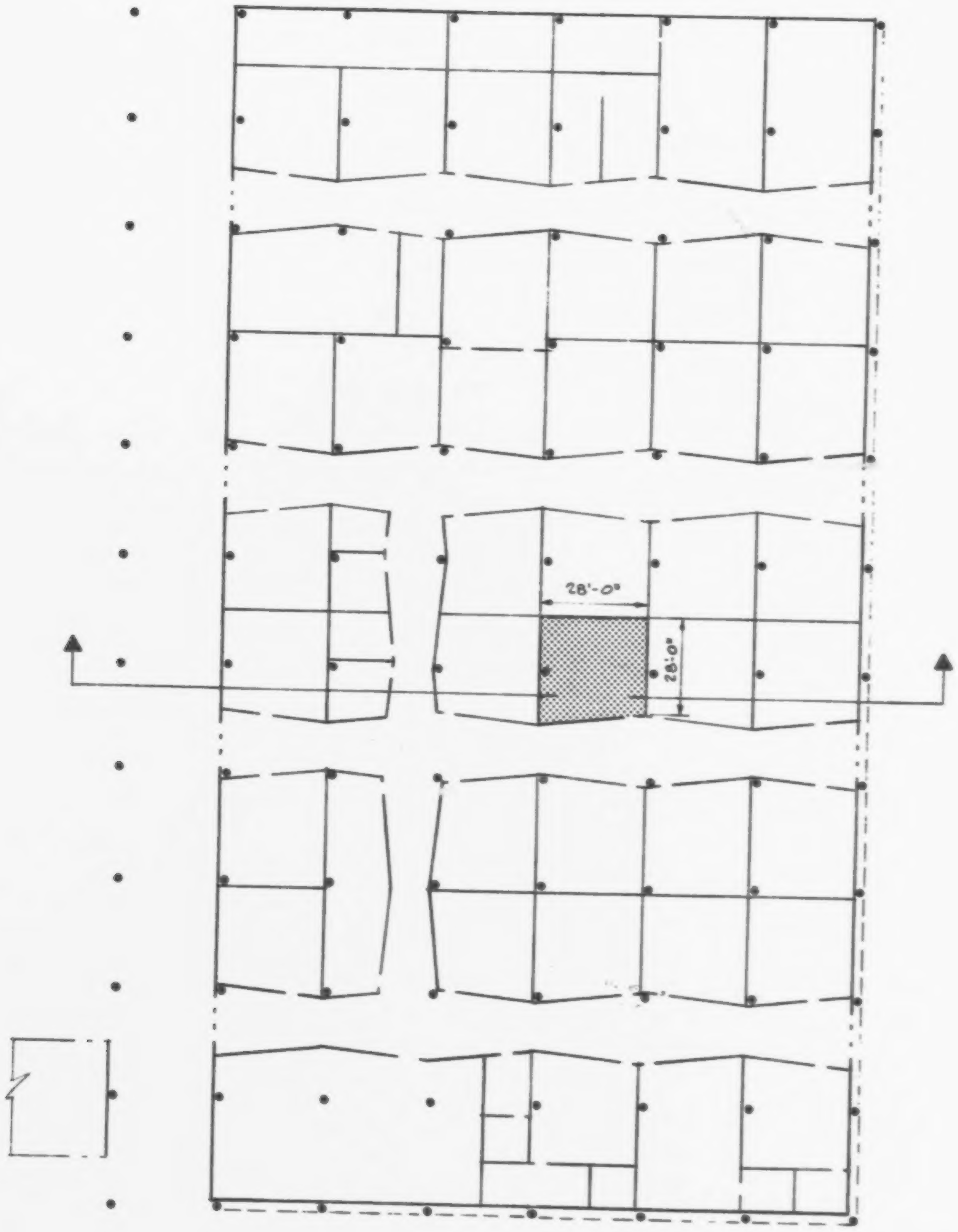
STUDENTS PRESENT BUT CLASS SILENT (Noise Levels in db)

	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Over-all Range cps	Average
13	52	50	48	46	46	57-61	58

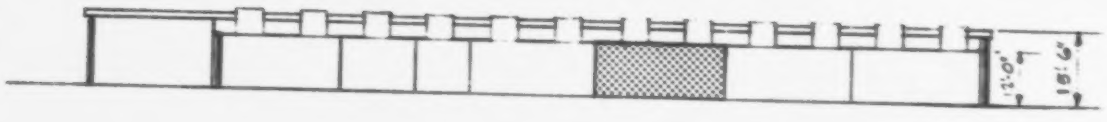
TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	13	33	47	7	0

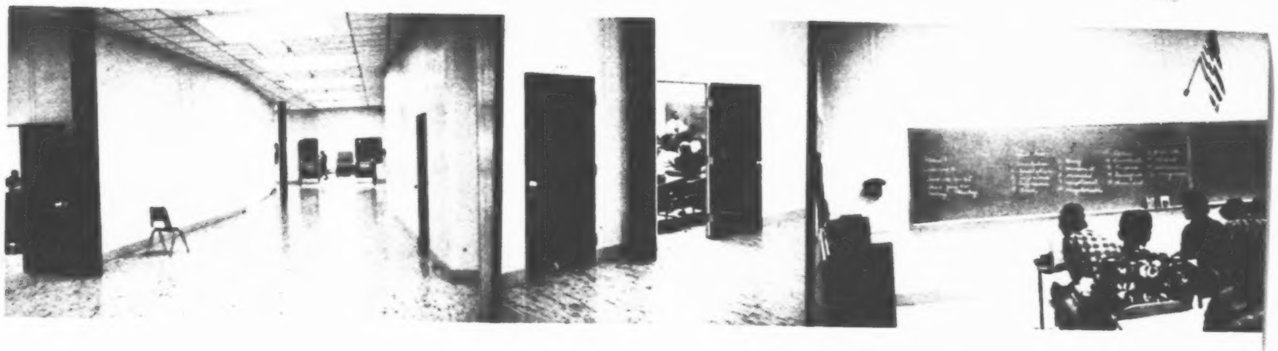
SCHOOL
4
PC



partial plan



section



This is a senior high school whose design and construction are virtually identical to the school designated as *5-PC*. Note the variation in the teacher opinion poll between the two schools. Most of the teachers of this school who judged it ***not acceptable*** did so on the grounds of its acoustics. School *5-PC* was not rated as ***not acceptable*** by any teachers. School *5-PC* was visited and analyzed on May 10, while School *4-PC* was subjected to the same examination on June 12, just a few days before the end of the term; the difference between the teacher opinion polls of the two schools may be a measure of frayed nerves at the end of the school year. Most of the teachers rating the school ***not acceptable*** reported difficulty in the use of audio-visual material because sounds were considered an interference in neighboring rooms; it was also reported by teachers that the interception of sounds by partitions was low. The administrator states, "From time to time minor complaints are heard concerning the noise factor, particularly in the use of tape recorders and motion-picture projectors. However, the number of comments of this type is no greater than the number heard in other schools with standard lath and plaster type construction (for partitions and ceiling)."

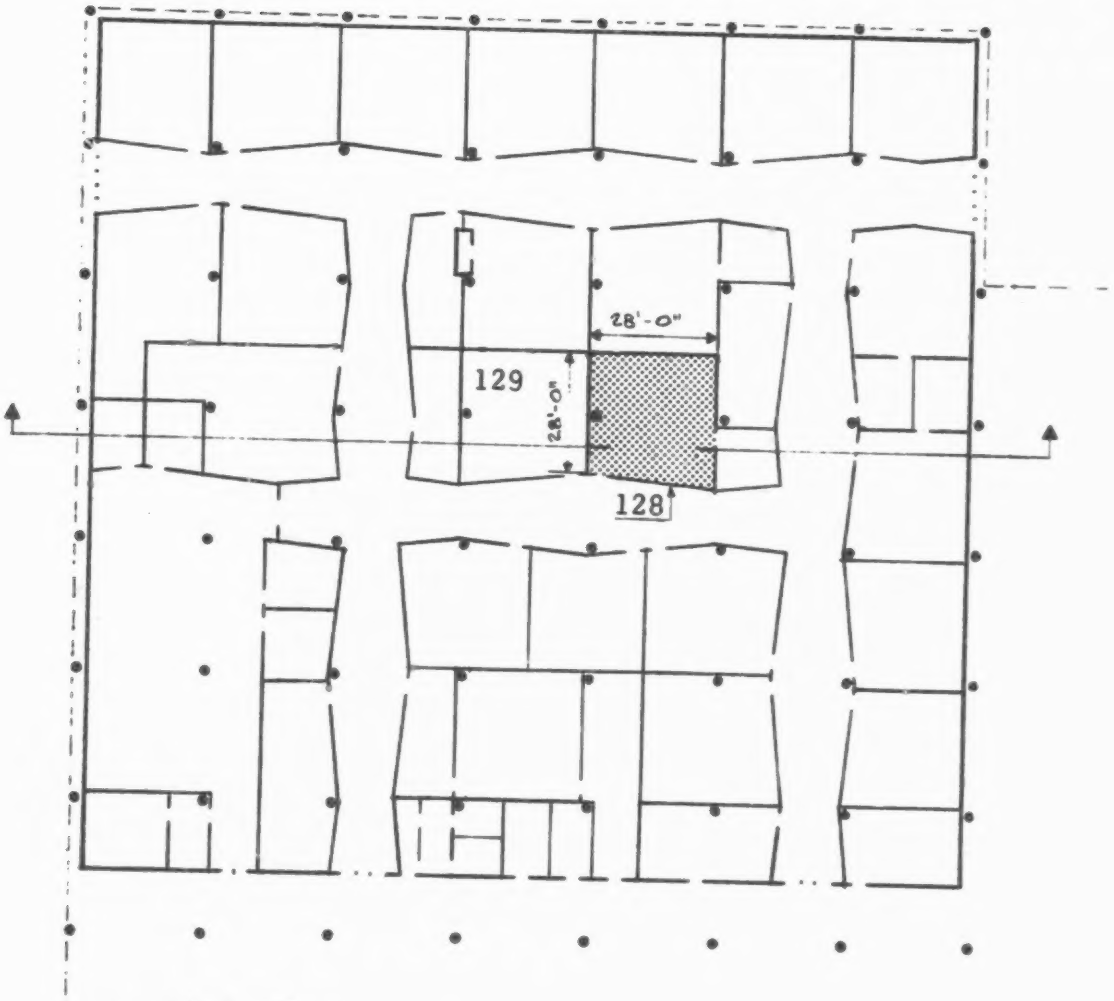
NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
Typical classroom	21	24	24	23	30	38	27

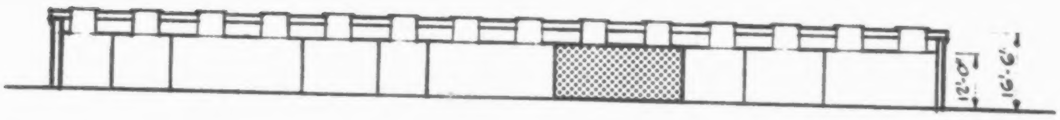
	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
	—	—	10800	1.51	.71

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	12	20	16	28	24


28'-0"
129
28'-0"
128

partial plan



section

This is a senior high school of the loft-plan type. Partitions are movable and are metal, unit-type. Ceiling construction consists of suspended aluminum grid which holds gypsum board panels that are treated with a sound absorptive material; the ceiling panels rest in the grid and are not fastened. Daylighting is provided by overhead glass block panels, and ventilation is entirely mechanical. Most of the unfavorable comment by the teachers is directed toward the ventilation system of the school; there is a general favorable opinion of the acoustical environment by the teachers. Quite frequently corridor doors are left open. Teachers report that on some occasions record players and sound films in neighboring rooms are distracting. Students are not critical of the acoustics of the school.

NOISE REDUCTION (NR) in decibels (db)

	75-150 cps	150-300 cps	300-600 cps	600-1200 cps	1200-2400 cps	2400-4800 cps	Average 75-4800 cps
129-128	23	28	29	30	32	34	29

	Articulation Index (AI)	Speech Interference Level (SIL)	Volume Cu. Ft.	Reverberation Time (RT) Sec. 500 cps	Optimum RT sec. 500 cps
129	—	—	9400	1.51	.69

TEACHER OPINION POLL (%)

	Excellent	Good	Satisfactory	Acceptable	Not Acceptable
	20	53	20	7	0

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GLOSSARY OF TERMS

Decibel (db)

The unit for measuring the relative intensities or levels of sounds. Related to a base, the level in decibels describes sound levels specifically, similar to temperature levels in degrees. The decibel refers primarily to sound pressure levels. Because of the hearing characteristics of the ear it does not necessarily define levels in *loudness* as heard.

Noise Reduction, or Noise Reduction Factor (NR or NRF)

This is the over-all amount of sound reduction accomplished from one room to another. It includes the transmission loss through a simple or complex barrier, plus a function of the area of the common boundary between the rooms and the total sound absorption in the second, or listening, room.

Period of Reverberation, or Reverberation Time (RT)

This is defined as the length of time it takes a sound of a given frequency, or pitch, to decay to one-millionth of its original intensity, or the length of time, in seconds, for a 60-decibel decay. Where a single period is given, unless expressed otherwise specifically, reference is usually assumed to be a pitch of 500 cycles per second.

Speech Interference Level (SIL)

This has been defined as the arithmetic average of the background or conflicting noise levels, in decibels, in the 600-1200, 1200-2400, and 2400-4800 cycles per second octave bands. It is expressed in decibels. In this survey the speech interference levels were arrived at by averaging the 600-4800 cycles per second octave bands, taken with the class present but silent.

Articulation Index (AI)

A measure of the ability to recognize speech components spoken by a speaker or speakers. In this survey it is used to refer to the degree of intelligibility with reference to speech sounds from other rooms. See more detailed discussion under this heading in the Analysis and Conclusions section.

Transmission Loss (TL)

This defines the number of decibels by which a sound on one side of a partition is reduced in transmission through it. It refers to the noise-reducing abilities of a simple or complex boundary, but it does not include effects of the area of the common partition or the amount of sound absorption in the listening room. It is not the same as the Noise Reduction or Noise Reduction Factor.

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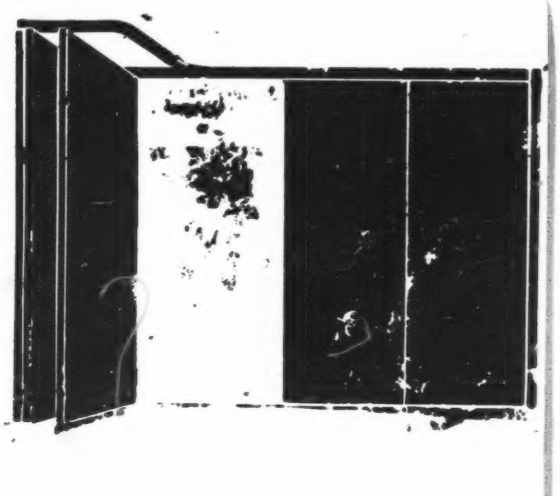

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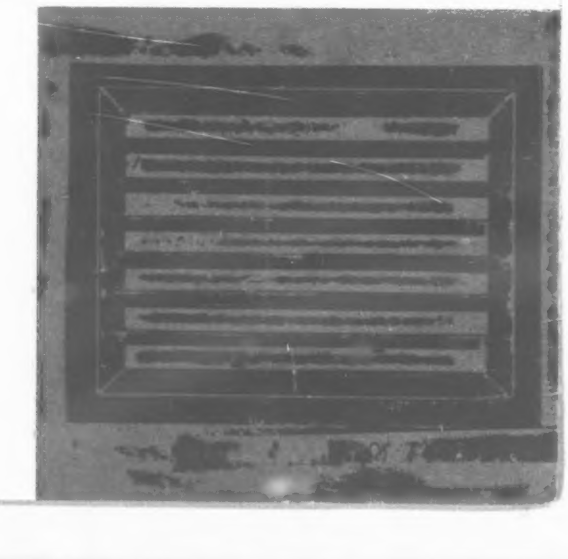

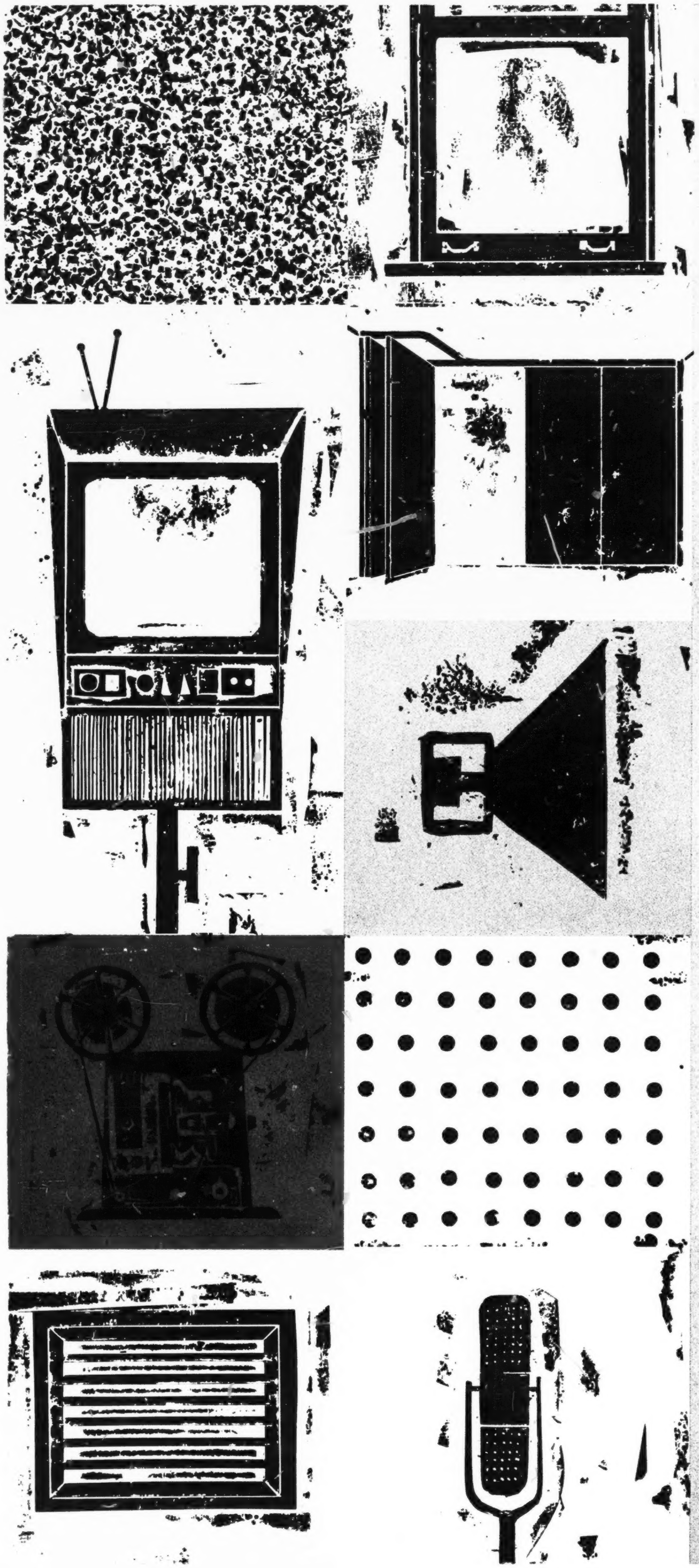

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